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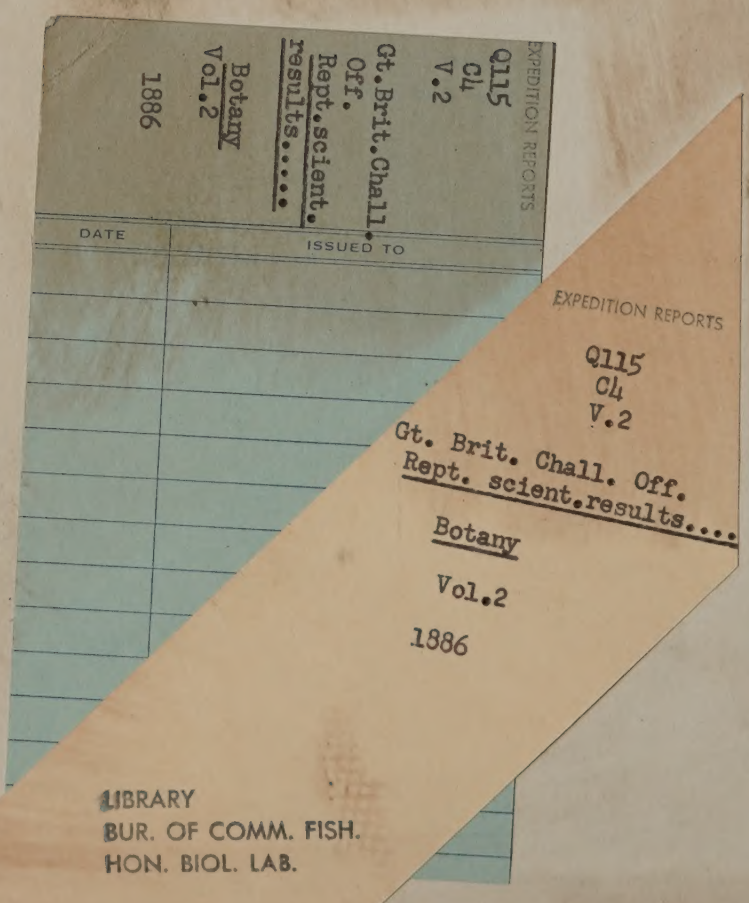

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VOYAGE OF H.M.S. CHALLENGER.

BOTANY—VOL. II.

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REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND THE LATE

CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

THE LATE

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH

DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

AND NOW OF

JOHN MURRAY

ONE OF THE NATURALISTS OF THE EXPEDITION

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I.—Report on the Diatomaceæ collected by H.M.S. Challenger during the years 1873–1876.

By Conte Abate Francesco Castracane degli Antelminelli, Rome.

(*The Manuscript was received in December* 1884.)

EDITORIAL NOTE.

This Volume contains the fourth and concluding Part of the Botanical Series of Reports on the Scientific Results of the Expedition, and is a Memoir by Conte Abate Francesco Castracane degli Antelminelli on the Marine Diatomaceæ collected during the Expedition. The Report was originally written in the Italian language, and was translated into English under the direct supervision of Conte Castracane; it has, however, been found necessary to submit this translation to considerable modifications of form before sending it to press. In some respects it would have been desirable had the Author included in the Report lists of the species found in the deposits and in the surface waters of different regions of the ocean; such lists will, however, be given in the Report on Deep Sea Deposits.

It was at one time hoped that an additional Report would be included in this Volume upon Pelagic Algæ other than the Diatomaceæ, such as Ocillatoriæ, Coccospheres, Rhabdospheres, and some other organisms which are regarded as Pelagic Algæ. The material brought home was, however, not extensive enough, nor in a sufficiently good state of preservation, to admit of the preparation of a satisfactory Report; indeed, it would not have been possible to add much to what has been said about these doubtful organisms in the Narrative of the Cruise, or to the remarks it will be necessary to make concerning them in the Report on the Deep Sea Deposits. An interesting account of these Pelagic Algæ may be looked for from the first Naturalist, who has the time and opportunity to examine them in the living state on board ship, immediately after having been taken from the waters of the open ocean.

John Murray.

Challenger Expedition Office, 32 Queen Street,
Edinburgh, *November* 14, 1886.

ERRATUM.

On p. 123, line 10 from top, for "*trocos*" read "*trochus.*"

THE

VOYAGE OF H.M.S. CHALLENGER.

BOTANY.

REPORT on the DIATOMACEÆ collected by H.M.S. CHALLENGER during the Years 1873–76. By Conte Abate FRANCESCO CASTRACANE DEGLI ANTELMINELLI.

PREFACE.

ALTHOUGH the group of the Diatomaceæ was almost unknown until within the last half century, the activity that has been exhibited in this very attractive department of research has of recent years been so great that many hundreds of different species have been already recorded. Two branches of the study, however, possess perhaps a more than ordinary amount of interest. Among the numerous types that occur in the more superficial waters of the ocean, or that have sunk to the bottom and now form part of the oozes of the ocean bed, many unusual forms which are the representatives of several of the most elegant of known genera have been met with, while many geological deposits of marine or lacustrine origin, and occurring in various parts of Italy and in Sicily, as well as several other regions of the globe, not unfrequently present rare and superb frustules.

Having for several years occupied myself with the careful study of many marine soundings and with the examination of various geological deposits, and having taken pains to procure frustules from various parts of the world for comparison with those found in such deposits by communicating with other well-known micrographers, I lost no time on the return of H.M.S. Challenger in expressing to the naturalists at the head of the Commission the desire that I might procure from them spare materials for the purpose of facilitating my work. The courteous assurance that this request would in due time be attended to afforded me great satisfaction, and this was still further increased when, after writing to Dr Radford of the importance of instituting a comparison between the Italian deposits and the Antarctic diatomaceous banks first made known by Sir J. D.

Hooker, I was informed by the late Sir Wyville Thomson that everything would be done to aid this investigation. The announcement which I received somewhat later from Mr John Murray that Sir Wyville Thomson proposed that I should undertake a systematic examination both of the littoral and pelagic Diatoms brought home by the Expedition caused me no little delight or surprise. The proposal, however, I gladly accepted, and although conscious of the arduous nature of the work, I resolved to spare no pains in making it as complete as the time at my disposal would permit.

The materials as intrusted to me consisted of about a hundred small bottles containing muds or oozes from different regions, together with several surface collections obtained by the use of the tow-net. The whole was in excellent condition, and the depth and position of the gathering, as well as the date when it was procured, were carefully recorded on every sample.

The time necessary for the preparation of illustrative slides from so many gatherings and for the determination of new genera and species has necessarily been somewhat long, but I am indebted to Mr Murray for an extension, more than once, of the period at first granted to me, and this has enabled me to make the present Report somewhat more complete than it otherwise could have been. It cannot be doubted, however, that among the great amount of material at my command many new or rare forms have escaped observation, and these may be published at a subsequent time as a supplement to the present work.

In several cases criticisms have been offered or emendations given of the definitions of previously known genera and species. As was to be expected from the examination of gatherings made in so many hitherto unexplored regions, the list of new species that have been established—some provisionally—is considerable, but care has been taken to limit these as far as possible. A few new genera have been founded, but on the other hand several old ones have been abolished, our recent advances in the knowledge of the Diatomaceæ being such as to reveal the inadequacy of the characters that have been hitherto regarded as of generic value. In all cases where the differences between any form and the already known typical species have been of a subordinate kind and quite insufficient to justify the introduction of new specific names, varieties have been constituted, but these instances are not very numerous.

Although in the earlier stages of my work it was my endeavour to record the various species that occurred in each gathering with a view of perfecting somewhat more fully our knowledge of the environments and geographical distribution of the various species, I soon abandoned this method, and have been satisfied by merely recording in most cases the locality from which the various species described have been obtained.

The plates have been prepared under my direct supervision by Signor Cesare Cerri, and to him my best thanks are due for the faithful manner in which he has executed the work. It is perhaps somewhat unfortunate that a natural classification has not been

followed in these plates, but this was impracticable, as the earlier figures had to be engraved before the entire collection was examined.

To the late lamented Professor Sir Wyville Thomson I lie under a permanent debt of gratitude for the opportunity afforded me of examining and reporting on this interesting group of organisms, and my best thanks are also due and rendered to Mr John Murray for the valuable aid of all kinds which he has given me in my work; as well as to Mr. John Rattray of the Challenger Editorial Staff for the care and pains he has taken with the proof sheets as they were passing through the press, and for many valuable suggestions. To Dr Radford, Mr J. A. Tulk, Dr Stolterfoth, and Mr Weissflog of Dresden, who have manifested the greatest interest in my work, and have often furnished me with valuable advice, I also lie under the deepest obligation, and last, but not least, to Dr James Rae, R.N., who has with the greatest liberality furnished me with many unique preparations of new and rare frustules.

Although no one can be more conscious of the many imperfections of the work than the author himself, it is earnestly hoped that these are not of a kind to derogate too much from its value as a work of reference on this exceedingly interesting branch of marine investigation.

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INTRODUCTION.

LIMITED CONDITION OF OUR KNOWLEDGE OF DIATOMS.

THE extreme difficulty of acquiring an adequate knowledge of Diatoms, owing to their small size and the impossibility of following attentively and registering every stage of their development under the microscope, renders the greatest care necessary in the observation of every phenomenon presented by the living species. As, however, the making of such useful observations is entirely fortuitous, the majority of the earlier investigators are found almost exclusively to have been satisfied with making a mere record of the different types occurring in their preparations, the most of which were purchased from traders in this department of microscopy, who vied with each other in procuring new or rare forms.

The eagerness of these observers to possess such novelties, with the view, in many cases, of designating new species by their own names, along with the too hasty work of the first discoverers of Diatoms, and especially of Ehrenberg, had the effect of introducing a nomenclature that was misleading, and of causing a confused synonymy that has been justly designated the opprobrium of the science. Against the continuance of this state of things Professor Walker Arnott raised an authoritative voice, going so far even as to declare that any researches relating to types found in the stomachs of molluscs and fishes, or obtained from marine soundings, were altogether useless. By thus acting it cannot be doubted that this naturalist exceeded all reasonable limits, but it is to be borne in mind that he did so with the view of putting a restraint on those who were too careless in conducting their investigations.

In the present state of our knowledge, one of the most important applications of an acquaintance with Diatoms lies in the field of Geology, where it serves as a guide in tracing the history of many formations which teem with their remains or impressions. Thus, although a siliceous bed may be found on the side of a mountain several hundred feet above the level of the sea, and although it may be in a position of notable inclination to the horizon, an accurate examination of the contained frustules may prove whether the deposit was laid down in fresh or salt water, and whether, in the latter case, it occurred in the open sea or in greater proximity to the land. Moreover, as the obliquity of the bed demonstrates the existence of subterranean forces of upheaval subsequent to its formation, so the presence in it of layers of chalk or clay point to a removal of

the diatomaceous growth from the area of deposition while these intrusive layers were being formed.

That the comparison of recent and fossil or semi-fossil species is very useful as a means of elucidating structural peculiarities cannot be doubted, yet the determination of species is a matter of great difficulty. Thus although two given forms may be readily seen to belong to the same genus, the points of difference between them may be merely *varietal* and not *specific*, hence it becomes necessary to give careful consideration to the real significance of these points. To those who hold that all organic forms are but modifications or evolutions of a monad or primitive cell, the existence of species is enigmatical and such differential features are of but secondary moment; while, on the other hand, to those who regard the slightest deviation from a typical form as sufficient justification for the creation of species, these characters become of great value. In any case, however, although it is often impossible to decide whether two closely allied organisms differ in a varietal or specific manner, the omission to record the existence of distinct structures, which tend to make the history of the given type more complete, is unjustifiable. For this reason the indication of every notable form will frequently be made, but modifications will very often be treated as varietal, and new species will never be founded save on the presence of two or more interesting differences existing side by side. Where these are established, or new varieties recorded, the arguments that lead to such a course will always be given.

With regard to the *geographical* and *bathymetrical* distribution of Diatoms, no definite results can yet be laid down on account of the very limited condition of our knowledge of marine forms. As to the former, however, the desirability of registering the locality from which every organism has been obtained as a means of facilitating future work is apparent. The bathymetrical range is a question of even greater difficulty, as only *living* species, and the depth at which they are found, can be taken into account. It may here be noted that the advantages arising from a careful record of the depth from which crustacea, corals, madrepores, &c., are obtained, are very great, as frustules recognised to be living by the presence of the endochrome are often found adhering to their surfaces, and thus facts may often be gathered that go to aid in the determination of the limits in depth of vegetable life.

The importance of prosecuting investigations in this direction is so great that a means of conducting experiments was suggested by me in March 1871.[1] I had repeatedly observed that, after exposing a vessel of water covered with a glass plate to the light for some weeks, small Diatoms and other unicellular Algæ appeared in it, and the same result was obtained whether the water were fresh or marine. As this growth could only have been due to germs pre-existing in the water, since carefully prepared artificial sea-water led to entirely negative conclusions, it is very probable that if, with a suitable apparatus, sea-water could be drawn from various depths, for example, at intervals of

[1] Esame microscopico e note critiche su un campione di fango Atlantico ottenuto nella spedizione del "Porcupine" nell' anno 1869, *Atti. Accad. Pontif. d. nuov. Lincei*, vol. xxiv. pp. 16–29, 1871.

50 metres (27 fathoms), the depths being in all cases carefully recorded, and if this sea-water could be placed in glass vessels covered with suitable glass plates and exposed to diffuse light, so as to avoid the great heat of the direct rays of the sun, after a month Diatoms might appear in some of the vessels. In this manner it is not unlikely that the bathymetrical limit of plant life might be fixed with approximate certainty. Moreover, the great facility with which this method of determination may be practised recommends it as one likely to aid in solving this important problem.

THE BIOLOGY OF DIATOMS.

This interesting group of organisms, the knowledge of which we owe entirely to the perfection of the modern microscope, has for upwards of half a century occupied the serious attention of naturalists.

To the entire series of forms the designation Diatomophyceæ was given by Rabenhorst and Bacillarieæ by Kützing, but the name of Diatomaceæ is now generally adopted.

Diatoms may be defined as unicellular algæ having a siliceous coat. Each organism forms a small box, the siliceous walls of which completely enclose a space; these walls in many, if not in all species, are formed by two distinct plates or valves, each possessing its own hoop, one of which embraces and slides over the other like the tube of a telescope or the lid of a box. This hoop, connecting zone or belt, may be single, double, or of complex structure, as in *Rhabdonema*, *Striatella*, and some other species, where it is formed of several hoops. Such a complete individual Diatom is called a *Frustule*, and it may be viewed from two aspects, to which, however, confusing terms have been applied. Thus Kützing and W. Smith, followed by the English micrographers, speak of *front view* when the organism presents its belt to the observer, and *side view* when its valve is next the eye; but, as the frustule is formed by two plates joined together, it seems reasonable to speak of the *front* of the box when the valve is seen, and of the *side* when the union of the two plates (*i.e.*, the belt) is presented. This latter opinion has been adopted by the German naturalists, who call Kützing's *side view* the *secondary view* and his *front view* the *primary*. In order, however, to avoid confusion, the terms *valval* and *zonal* might be applied according as the valve or connecting zone is next the observer.[1]

[1] The following arrangement will serve to show the relationship between these various terms:—

(*a*) Front view (Ralfs, W. Smith, &c.), *i.e.*, hoop next observer =
- Lateral surface (Ehrenberg).
- Primary side (Kützing).
- Secondary side (Rabenhorst).
- Zonal view.

(*b*) Side view (Ralfs, W. Smith, &c.), *i.e.*, surface of valve next observer =
- Dorsum and venter (Ehrenberg).
- Secondary side (Kützing).
- Primary side (Rabenhorst).
- Valval view.

The siliceous cell of the Diatom is filled with finely granular *protoplasm*, as may be seen after treatment with water slightly acidulated with hydrochloric acid. This causes the protoplasm to contract so that a vacant space appears along the sides of the frustule. The protoplasm encloses a coloured substance called *endochrome*, as well as a few round granules of an oily nature which dissolve under the action of ether or carbon bisulphide.

The endochrome is composed of chlorophyll and diatomine or phycoxanthine,[1] but of these the former is the more interesting, as it is capable, under the influence of light, of decomposing carbonic acid and evolving oxygen. The endochrome is of a greenish-yellow colour, and occurs in the form of bands, granules, or rounded masses which may be arranged irregularly or in radiating lines.

The appearance which this endochrome assumes in the same species is not always identical, and frequently, when it occurs as an amorphous mass, it becomes subsequently divided into numerous granules of equal size and definite outline. That these are to be regarded as so many perfect embryonal cells which are destined to reproduce the parent form cannot be doubted (see pp. 7, 8).

In addition to the endochrome and oleaginous substance, there is, in the centre of the cells, a protoplasmic mass distinguishable by its density from the protoplasm which occupies the rest of the interior of the Diatom. This is called the *Cytoblast* or *Nucleus*, and in its turn encloses the *Nucleolus* in its inactive condition, as may be demonstrated by the action of a very weak solution of chloride of gold.

The cytoblast and the nucleolus certainly exist in all Diatoms, but it is not very easy to distinguish them in small forms. In large species, however, such as *Striatella unipunctata* and a few *Amphoræ*, these structures may be readily seen, and in these the cytoblast may be observed to possess a stellate form having filaments resembling the pseudopodia of *Difflugia* or other Infusoria which sometimes extend to the extremities of the frustule.

Diatoms are solitary or gregarious, free or fixed. The fixed forms are attached by means of a peduncle which may be simple or branched, or they may be enclosed in a cyst, fastened on a small cushion, or embedded in a gelatinous substance which forms a frond either in the form of a simple or compound tube, of a flattened plate, or globular mass. In seriate species the frustules may be arranged either in a lineal or lateral manner. They are also often met with in the form of zigzag chains, adhering to each other by means of small angular cushions, as in *Tabellaria*.

The substance which exists in the form of a definite frond resembling a higher alga, being either ramified, ulvaceous, tubular, saccate, or mucilaginous and amorphous, and

[1] Sachs' Text-Book of Botany; Millardet and Kraus, *Compt. Rend.*, vol. lxvi. p. 505; Askenasy, *Botan. Zeit.*, 1869, p. 799; Pfitzer in Heft, ii. *Botan. Abhandl.*, edited by Hanstein, Bonn, 1871; *Quart. Jour. Micr. Sci.*, 1872–73.

which encloses a greater or less number of regularly or irregularly disposed diatomaceous frustules, was designated by Brebisson by the name of "Coleoderma." It is to be noted, moreover, that solitary and free Diatoms are not completely devoid of external mucus, but, on the contrary, are surrounded by a thin stratum of this substance. This becomes manifest when their movements in water coloured with indigo are observed under the microscope, inasmuch as the granules of coloured matter do not come into immediate contact with the Diatom, but leave a thin translucent area surrounding the frustule.

But the most singular and curious phenomenon observable in some species, and one which misled their first observers so far that they considered these organisms to be of an animal nature, is the rectilinear motion with which, among others, the *Naviculæ*, the *Cymbellæ*, &c., are seen to advance in the direction of their long axis and to return along the same line. The strongest magnifying power, the most accurate and careful application of the most perfect microscope, and the most skilful methods of observation, have failed to discover the existence of any special organs of locomotion. This being so, the most probable and generally accepted hypothesis suggested in explanation of the movement is that the Diatom, in order to obtain the silex which constitutes its walls, must continually absorb and reject the water which has in solution imperceptible traces of the siliceous substance, and that the consequent action and reaction thus exerted upon the light frustule suspended in the watery medium, determines its alternate forward and backward movement.

Besides this phenomenon of motion another circumstance connected with these interesting organisms early attracted the attention of naturalists, namely, the extreme delicacy of the details with which their valves are ornamented. There is probably not a single Diatom which, when examined by the best microscopes, does not show the surface of its valves to be adorned by exceedingly minute granules, generally arranged in lines which are usually spoken of as "striæ," although properly they are lines or rows of points.

That these striæ, however, are sometimes perfectly continuous cannot be denied, although some naturalists assert that the appearance of a continuous streak is purely illusory, the so-called streak being but the expression of confluent granules. In this connection it is to be noted that the phenomenon of diffraction produced by the obliquity and intensity of the illumination has occasioned a belief in the confluence of the granules of pinnulæ, &c., for example in *Pinnularia major*, Raben., as such a result can be obtained at pleasure in that and other frustules. This consideration, moreover, has led some to deny that there is any value in the division of the Naviculaceæ made by Ehrenberg when he instituted the genus *Pinnularia* for navicular forms having pinnulæ or coarse continuous striæ, and limited the idea of *Navicula* exclusively to navicular forms adorned by rows of granules.

Like the quality and delicacy of the ornamental details, the forms of the valves of

Diatoms vary greatly. These are generally more or less convex on the outside and concave on the inside, increasing in this manner the capacity of the cell and at the same time enabling it more readily to resist the external pressure which would otherwise tend to crush it. Not only are the forms of the two valves in most cases symmetrical with each other, but each valve is divided in many species into two similar portions by a central rib, called a "raphe," which serves to strengthen the valve.

In the centre of this raphe, and sometimes at its two extremities, swellings called "noduli" often occur. The central nodulus, instead of being round, is sometimes extended so as to form a kind of cross which is named a "stauros."

Although in a great number of species a central raphe occurs, in many others no such structure is to be found. Hence, upon the presence or absence of this raphe, Professor H. L. Smith has proposed a new classification of Diatoms, distinguishing them into *Raphidieæ*, *Pseudoraphidieæ*, and *Cryptoraphidieæ*. It is to be remarked that this classification has the defect of not being natural, and, moreover, it would seem that the *Cryptoraphidieæ* should be called *Araphidieæ* or *Anaraphidieæ*, inasmuch as none of the types included exhibit traces of the existence of a raphe or of any other analogous arrangement. Nevertheless, since this system has the merit of simplicity, and has already been adopted by the Austrian naturalist Albert Grunow, and by Dr Henri van Heurck in his Synopsis des Diatomées de Belgique, it will be followed in the present Report.

Diatoms, like all other living organisms, multiply and reproduce themselves. Multiplication, however, is not to be confounded with reproduction, but is to be understood as an extension of individual life. Multiplication by duplication or division occurs in many members of the vegetable kingdom; on the other hand the process of reproduction is common to every living thing. That multiplication by duplication is of frequent occurrence in Diatoms is proved by the fact that it has been already observed in forty or more different species, yet it would appear that it ought to be regarded not as normal but as exceptional. This process, which is also called fissiparous division or temnogenesis, takes place as follows: (1.) the nucleus or cytoblast becomes bisected; (2.) a central contraction of the internal protoplasmic mass takes place, and proceeds so far that the latter becomes completely divided; and (3.) a double wall or diaphragm, which contemporaneously extends to the circumference in a direction normal to the ring or cingulum, is formed. In this manner the primitive mother frustule gives origin to two perfect daughter frustules, each of which is provided with an old and a new valve, the latter being somewhat smaller in diameter than the former as its hoop is embraced by that of the old valve. The process of duplication, as it progresses, must in this way lead to a marked diminution of the diameter of the new frustules, and in a short time these would become so small that they would be no longer characteristic of the species. In order, however, to counteract this progressive diminution it is to be noted that the siliceous walls

of the frustules increase by reason of the process of fission. Dr Pfitzer[1] of Bonn, by denying the possibility of such growth, was induced to imagine the theory of the existence of auxospores, and to believe that these constituted the only real reproduction of Diatoms by a sexual process. According to this observer, after the frustules had, in the succession of divisions, reached the smallest dimensions compatible with the species, the contents of the small frustules escaped and united with each other so as to form one or two sporangia. Within these one or two sporangial frustules called auxospores appeared, and by their larger dimensions brought the Diatom to the beginning of another series of new graduated forms. But such a theory, taken in a general sense, and assumed as the process of reproduction common to all genera of Diatoms, is fundamentally false, because it rests on the gratuitous supposition that the diatomaceous walls are incapable of any increase in size. That such an increase, however, does take place has been proved by the Rev. Professor W. Smith in his classic Synopsis of the British Diatomaceæ (plate lii. fig. 335), where some sporangial frustules of *Orthosira dickieii* are represented in which it is evident that the siliceous walls increase with the growth of the contents. It is also to be noted in this connection that the distinguished Hugo von Mohl maintains that the cytoderm of a Diatom is not entirely inorganic, but only an organic membrane which is impregnated with silex, it having been already shown that silica is sometimes substituted for carbon in the formation of cellulose.

Again, if during the process of duplication an expansion of the cell wall did not take place, a hundred frustules of a Fragilarian filament would exhibit some difference in their longitudinal diameter. But no such difference is observable. Moreover, as it is impossible to understand the formation of the two new dividing walls in the centre of the parent cell in all their minute details unless it be admitted that the new frustules are stereotyped upon the old ones, it follows that such a process cannot be verified except in the genera in which the two valves of the frustule are perfectly identical in a symmetrical position. It is to be remarked that fissiparous division has not yet been observed in a single case to form an exception to the above rule.

Finally, against the theory which regards the sporangial frustule as destined to initiate a new descending series, Dr Wallich[2] remarks that that frustule, instead of being, as heretofore assumed, the primary or parent frustule of a new and vigorous generation, constitutes in reality the expiring phase in the life of an old one. Professor H. L. Smith seems to be of the same opinion, for, considering the possibility of *Stauroneis phœnicenteron*, Ehrenb., being a sporangial form of *Stauroneis gracilis*, Ehrenb., he points out that it is only an abnormal and transient form from which the *Stauroneis gracilis*, differing from it so much as it does, could never originate.

[1] Untersuchungen über den Bau und Entwickelung der Bacillarien (Diatomaceen), Bonn, 1871.

[2] On the Relation between the Development, Reproduction, and Markings of the Diatomaceæ, *Month. Micr. Journ.*, vol. xvii. p. 61, 1877.

In considering the process of reproduction, it is to be noted that the phenomena recorded during a fortunate observation in one case only cannot be regarded as typical for the entire group. It has, however, been perfectly established that reproduction can take place by means of two conjugated frustules, or by the two valves of the same frustule separating themselves so that the contents form a globular mass or sporangium, within which the formation of one or more young frustules takes place. These young forms sometimes exhibit duplication or fission, but this does not always happen, nor does it occur in all frustules. On the contrary, some species give rise to very minute frustules which in their turn form a new progeny. Thus when the endochrome occurs not in a more or less amorphous condition but as numerous rounded masses of equal size and definite outline, the frustule is to be regarded as sporiferous, the rounded masses representing so many sporules that are destined to reproduce the species. The escape of these sporules has been observed by Rabenhorst in a species of *Melosira*, by O'Meara in a *Pleurosigma*, and by myself in a *Podosphenia*, while Dr Cohn, as noted by Dr Pfitzer, saw a winged *Amphiprora* emitting small frustules from which the species could be recognised.

It is further to be borne in mind that diatomaceous sporules will gradually develop into the typical frustule either internally in the parent frustule, or externally in the sporangium. Sometimes the parent frustule takes the place of the sporangium, in other cases the sporangium is the production of the Diatom, destined for the incubation and maturation of the sporules.

These sporules are emitted in a free and solitary condition, but they are sometimes seen in couples, as in *Mastogloia*. Here each couple is enclosed in an oval cyst, and all stages of development, from two minute oblong greenish corpuscules up to large fully formed frustules, can readily be traced. All the couples are immersed in a dense gelatinous mass with which no extraneous bodies are mixed. Numerous round sporules have also been observed to form a mass, and transitional stages have been traced from the round green granular condition to that of spherical hyaline cysts which included a number of small but distinct *Naviculæ*. Among the cysts some were observed to move by means of two very slender flagelliform threads, and these must be regarded as real zygozoospores.

It seems evident that the process of reproduction by means of sporules is the only one that can explain the enormous rate of multiplication of the majority of the Diatomaceæ, while the other processes of duplication and reproduction will account for the greater rarity of some forms. Viewed from a physiological standpoint, therefore, sporular reproduction is of the highest importance, as by this means countless individuals are formed, all of which co-operate in supporting animal life by giving off the oxygen which is essential for the existence of the latter.

THE GEOGRAPHICAL DISTRIBUTION OF DIATOMS.

Diatoms are to be found at all seasons covering with a mucilaginous coating of an olivaceous green colour the watery surface of fountains and other damp places, and they have been seen by me to live in a small aquarium without the least sign of inconvenience for a space of three days, although all the water remained in a frozen state.

Marine Diatoms flourish in all latitudes and at all seasons of the year in the warmest and coldest seas; it is well known that they are so abundant in the Frigid Zones as sometimes to colour the surface of the sea and to tinge with a peculiar hue the blocks of floating ice. Seeing that they are capable of surviving in conditions so diverse it is difficult to believe that any fixed laws of geographical distribution can be discovered with respect to them; on the contrary, it might rather be supposed that the continuity of adjacent seas, the surface and submarine currents, the movements of tidal waves, the existence of periodical and other winds, the traffic of ships and the movements of fishes, would all tend to facilitate or bring about the mingling of local floras. It is true, indeed, that, since the temperature of the sea is nearly constant at great depths, an actively moving Diatom has only to sink deeper or approach more closely to the surface in order to find the temperature best suited to its nature and most favourable for its development, its vertical range of motion being limited, among other things, by the depth to which sunlight penetrates, this being assumed to be necessary to its existence. Since, moreover, the quality possessed by organic beings of adapting themselves to conditions of life different from those in which they came into existence becomes greater as the position occupied by the organism in the scale of life becomes lower, it is by no means easy to understand how, during the long course of centuries, the different types have not been distributed far and wide and rendered common inhabitants of all seas.

That several distinct floras nevertheless do exist may be confidently affirmed, although it may be premature to determine finally the question of distribution according to the genera and species that inhabit different areas. The distinction, for example, between pelagic and littoral Diatoms has already been clearly recognised, and the importance of the application of this knowledge to geological problems has been fully pointed out.[1]

Again, as regards the occurrence of distinct chorological floras it may be noted that, by those conversant with Diatoms, collections from the Antarctic Ocean would not be confounded with those from the Sea of Japan or from the Arctic Sea, nor would the flora of the Adriatic or of the Mediterranean as a whole be mistaken for that of the Indian Ocean, although some of the same genera and species might exist in all.[2]

[1] See *Atti. Accad. Pontif. d. nuov. Lincei*, Anno xxxii., Sezzion 1ª, December 15, 1878.

[2] See Narrative of the Cruise, vol. i. p. 933.

It must, indeed, be admitted that the presence of a single common form in two widely distant seas—such as the Arctic and Antarctic Oceans—throws a difficulty in the way of admitting different local floras. Thus, if only a single species could, by currents or from any other cause, have migrated in one or more stages from one point to another, it must follow that the general mingling of the various marine genera and species is reduced to a mere question of time. It remains, however, to be proved that in the polar seas the Diatoms that occur, though admittedly belonging to the same genus, are also positively of the same species. On account of our imperfect knowledge and of our limited means of observation, it cannot be asserted that two such frustules do not form two distinct species, though their specific characters may *appear to be identical.*

But allowing that some common species do exist in widely separated oceans, it may be safely concluded that, since the complete fusion of all marine floras has not taken place in the course of the thousands of centuries during which Diatoms have existed, it will not happen for many ages to come.

What, then, is the meaning of setting a limit of any kind to the habitat of marine species? In the present state of knowledge no definite information can be offered, and it may be long before the circumstances under which the development of one diatomaceous form takes place in a given locality, to the exclusion of another, are fully known. Remembering, however, the great facility with which Diatoms adapt themselves to the most varied conditions of life, the numerous opportunities afforded for the distribution of microscopical marine organisms, and the occurrence of different temperatures at different depths in the sea in the same latitude, it may with some probability be asserted that the extension of species in the sea is determined to a great extent by the temperature of the water. If such were not the case it would not be easy to explain why the Diatoms of temperate seas should not be found in company with glacial forms, while, on the other hand, it must be expected that, apart from considerations of pressure and other physical conditions of environment, the species of the polar seas should be met with in great depths in temperate waters.

Another circumstance which may have tended to prevent the fusion of local microfloræ into a universal one may here be referred to, having been recently pointed out by Mr John Murray in a preliminary report of observations made on board the Challenger, read before the Royal Society of London.[1]

"In the Southern Ocean," says Mr Murray, "south of Kerguelen, in the Arafura Sea, off the coasts of Japan, New Guinea, North America, and in enclosed bays and river deltas,—in short, wherever the specific gravity of the sea is low from an admixture of fresh water, we have met with very many Diatoms on the surface."

After examining an abundant supply of materials from the Red Sea I have been led to

[1] On Surface Organisms and their Relation to Ocean Deposits, *Proc. Roy. Soc. Lond.*, vol. xxiv. p. 533, 1876.

the same conclusion. Here Diatoms of different species do occur, but they are relatively scarce—a circumstance which may be explained by the fact that no large rivers flow into this area to compensate for the enormous evaporation to which it is subjected on account of its vicinity to the equator, so that its waters are more dense and more heavily charged with saline constituents.

If this explanation be correct, it follows that the warmest, and, by their great evaporation, the most saline parts of the ocean, serve as all but insuperable barriers to the mixture of different floras, so that each may retain almost indefinitely its own special characteristics.

Silica, of which the walls of Diatoms are composed, exists in all kinds of water, but generally in so small quantities that its proportion cannot be determined. Hence Professor Bischoff has lately asserted that siliceous Infusoria—meaning thereby Diatoms—must take into their interior, in order to form their valves, the same quantity of water, in proportion to their mass, as would be swallowed by a man who drank a cubic foot per second.

If water were absolutely devoid of silica, Diatoms could not exist, but this and other important substances are being continually carried into the sea by rivers. The calcareous material present in the ocean goes to form the tests of Foraminifera and Crustacea and the coral formations of tropical zones, while the silica is removed by Polycistinæ, Radiolaria, certain Foraminifera, Spongidæ, and Diatoms.

The secretion of lime takes place, according to Mr. Murray, most actively in the warmest and saltest seas where solar evaporation is most rapid, and it is a fact no less striking that the greatest abundance of Diatoms is found in localities where the water is of relatively low specific gravity and the temperature in some instances likewise low.

THE BATHYMETRICAL LIMIT OF DIATOMS.

Problems of distribution are, from the very nature of the conditions, much more difficult to solve in the case of marine than of terrestrial organisms, and with regard to the Diatomaceæ it has hitherto been impossible to define the greatest depths at which they are capable of surviving in the various ocean basins. A method has been already referred to by the application of which it may be proved whether they do vegetate at any given depth (pp. 2, 3), but in addition to this, careful records should be made of the occurrence of living frustules on fragments of corals, shells, &c., which are brought up from a known depth, as a check is thereby placed on the experimental working out of this most important question.

From a knowledge of their physiological functions of decomposing carbonic acid and evolving oxygen under the influence of sunlight, it may be inferred that Diatoms cannot live where light is unable to penetrate. With this theoretical conclusion daily experience

is in perfect harmony, for these minute organisms multiply with extraordinary rapidity in positions illuminated by and exposed to the sun, but abound less in shady places and are never found to vegetate in darkness. Hence in the great depths of the sea, to which light, because of absorption, cannot penetrate, only dead valves of Diatoms will be found.

I have given at length in another communication[1] arguments based on the existence of Diatoms in the stomachs of abyssal Echini, which seem to me to show that these organisms might possibly live at depths of 1340 fathoms, and that sunlight might penetrate to greater depths than at present supposed. Mr. Murray, however, informs me that it was observed during the Expedition that the great majority of deep-sea animals lived by eating the surface layers of mud or ooze forming the bed of the ocean, which usually contained a large number of the remains of surface animals and Diatoms; his opinion is that a small amount of organic matter is carried down with the dead shells and frustules from the surface waters where the organisms lived, and that the deep-sea animals obtain their nutriment from it. Had Diatoms been observed in the alimentary canal of fishes, they might have been obtained at less depths. As, however, Echinodermata live only on the bed of the ocean itself, it must be regarded as very probable that these frustules formed a portion of the food of these animals.

The significance of such observations in connection with deep-sea life is of the highest value, as tending to explain the existence of animals in a normal state at the greatest depths—a fact that has already been recognised by many marine scientific expeditions organised by Great Britain, the United States, and other nations. The existence of life in darkness must be regarded as exceptional, although there are numerous and well-known instances of rare and blind animals (such as *Proteus*) which inhabit caves into which no light can penetrate.

On the other hand, the facts that the eyes are fully developed in some of the animals that inhabit the deep sea, and that they possess beautiful and brilliant colours, seem necessarily to imply the presence of light in these abysses, since, in its absence, the organs of vision should become atrophied, and the colouration be more or less dark.

These conclusions have been universally accepted, but the belief that light could not penetrate to such depths on account of absorption in its passage through the water afforded ground for advancing hypotheses to explain the facts, the reality of darkness at the bottom not being doubted.

Among these hypotheses it has been held that the phosphorescent light given off by the bodies of abyssal animals is sufficient to make up for the absence of sunlight. Although the weight of this suggestion is very great, it may be asked—Can marine animals emit light when alive and in their normal state? Fishes, Crustacea, and other marine creatures are phosphorescent when they are dead or at least out of their proper medium.

[1] Nuove Osservazione sulla Profundita cui giunge la Vegetazione delle Diatomee nel Mare.—*Mem. Pont. Accad. d. Nuov. Lincei*, vol. i. 1885.

The sea on dark nights is lighted up under the strokes of oars, in the track of boats and ships, along the shores, and among the breakers, and it is known that this attractive phenomenon is chiefly due to myriads of *Noctilucæ*, *Peridinia*, and other small pelagic forms; yet these organisms emit a momentary splendour only when they are disturbed by an extraneous body or by the mechanical action of the waves, although the highly specialised apparatus in *Nyctiphanes norvegica*[1] is apparently an evidence that in some animals this power is under the influence of the will. Mr. Murray also informs me that he has observed very many animals emit phosphorescent light in the stillest waters without any apparent external stimulant.

Granting that the phosphorescence of abyssal animals is a normal characteristic, it must still be proved that it is not only sufficient to dispel the darkness so effectively as to explain the presence and development of visual organs, but that it is capable of so great actinic action as to determine the vivid colouration above referred to.

Just as the bathymetrical limit of marine life, which was laid down at 300 fathoms by Professor Edward Forbes, is now no longer accepted, so the distance to which light can penetrate may prove to have been misunderstated hitherto, and should, in the interest of truth, be re-examined by physicists.

It is stated that in the passage of light through sea water the first rays to be absorbed are the calorific, then the luminous, and lastly the actinic or chemical, which are precisely those that have most influence on colours and on chlorophyll and consequently on vegetation in general, and attempts have been made to fix the limit of the penetration of light by observing the gradual descent of a white object, and by noting the moment when that object could no longer be discerned. But even although the distance thus obtained be more than doubled, and the observer placed in a condition to be in no way influenced by the external light, such observations are not very reliable.

Since several indications of the influence of light in marine abysses now exist, an explanation of the manner in which it can penetrate to even very great depths should be sought after.

An interesting observation may here be noticed. When two French aeronauts were recently crossing the English Channel, and when at a great height above its surface, they were struck by the circumstance that its bed could be distinctly seen, and that all the details of the irregularities of its bottom could be traced. It may be said that the depth of this narrow belt of water is not to be compared to that of the great oceans, but assuredly even its depth could not be *seen* by an observer near the surface, and perhaps it is not less than the limit hitherto placed on the distance to which light can penetrate.

[1] Narr. Chall. Exp., vol. i. p. 743.

HYPOTHESIS ON THE FORMATION OF BANKS AND DEPOSITS OF DIATOMS.

In 1876 Mr Murray read before the Royal Society of London a Preliminary Report [1] on Oceanic Deposits, appended to which is a map in which the existence of a bank formed almost exclusively of the siliceous remains of Diatoms is indicated; and further details have been more recently given by Mr Murray in the Narrative of the Cruise.[2] This bank extended between lat. 60° 52′ S., long. 80° 20′ E., and lat. 53° 55′ S., long. 108° 35′ E. It therefore measured not less than 1700 miles in length.

Such accumulations lead one to inquire how it is that Diatoms which vegetate in all seas should accumulate in this manner in particular localities which are in all probability few in number, since similar formations were not recorded by the naturalists on board the Challenger in any other region.

A Diatom as soon as it ceases to live is no longer supported by the globules of oxygen which it evolves and which adhere to it, but is left to the mercy of the waves, and in virtue of its own weight, it sinks to the bottom, which it will reach in a relatively short space of time, notwithstanding the disturbing tendencies exercised by oceanic currents, as the density of the water is but little affected by the constantly increasing pressure. It is, moreover, not improbable that the cooling and consequent descent of the surface waters in the neighbourhood of the Antarctic ice, facilitate to some extent the sinking of the dead frustules and their accumulation on the bottom in these regions.[3]

It is a matter of very considerable importance from a geological point of view to determine exactly the conditions under which diatomaceous deposits like those discovered by the Challenger are laid down, inasmuch as what is now taking place in the Antarctic supplies a clue to the elucidation of the phenomena which took place in remote epochs when similar marine diatomaceous banks were laid down.

Italy affords a very interesting example of such formations. For several years it has been known to the scientific world that, in the celebrated sulphur mines of Sicily, siliceous schists occur which not unfrequently contain specimens of fish. These schists have been found to consist very largely of Diatoms and Radiolaria, so that their marine origin cannot be doubted.

More recently the curiosity of palæontologists has been attracted to a locality in Central Italy called Mondatino, in Montefeltro, where, among the strata of siliceous marl, a number of fishes were found in schists, which, like the former, were extensively formed of the remains of marine Diatoms and of the skeletons of Radiolaria and Polythalamia.

This formation lies along the spurs of the Apennines, extending on the one side as

[1] *Proc. Roy. Soc. Lond.*, vol. xxiv. p. 471, 1876. [2] Narr. Chall. Exp., vol. i. p. 432.
[3] Exploration of the Antarctic Regions, *Scottish Geographical Magazine*, vol. ii. p. 537.

far as the right bank of the Savio above Cesena, and on the other as far as the hills which flank the valley of the Misa above Sinigaglia. It also occurs at the extremity of the peninsula in the province of Catanzaro.

The microscopic examination of the Diatoms contained in these deposits warrants the conclusion that they belong to the same formation and constitute so many tracts of the same bank, which, though as yet imperfectly known in all its parts, probably extends over the whole of Italy from Sicily to the vicinity of the most ancient Jurassic formation of the Alps.

It may perhaps prove to be an interesting problem for the geologist who possesses a knowledge of the palæontology and stratigraphy of the lands which surround the basins of the Mediterranean and Adriatic Seas, to compare this marine tripoli with the diatomaceous deposits of the Antarctic, and to endeavour to determine the directions of tertiary oceanic movements, and compare them with those now prevailing in the Southern hemisphere.

In opposition to the hypothesis that has just been advanced, it is to be noted that Mr Murray is of opinion that the great Antarctic diatomaceous bank is but a portion of a much more extensive formation which girds the Antarctic Pole.[1] I believe, however, that sufficient proof of the existence of this belt has not yet been obtained, and that should it exist the circumstances that bring about such a formation would remain to be determined. It is true, indeed, that Sir Joseph D. Hooker, during the expedition of the "Erebus" and "Terror," discovered, between the parallels of 76° and 78° S. lat., a bank of Diatoms 400 miles in length and 120 miles in breadth, but such a discovery cannot be regarded as sufficient to prove the uninterrupted extension of the deposit around the Antarctic Pole. The bank found by the Challenger naturalists did not extend beyond 60° 26′ S. lat., and was succeeded by a deposit of blue mud, which, however, contained many Diatoms, and may be continuous with that observed by Sir J. D. Hooker. Finally, it may be noted that should such a singular diatomaceous annulus gird the South Pole its counterpart might be expected in the Arctic Sea. Yet, although this area has been much more explored than the Antarctic, and although it is much less deep, so that dead frustules might much more readily reach its bottom, no such ring-like deposit has been discovered. Mr Murray points out that this is probably to be accounted for by the Diatoms being much less numerous in the surface waters, and by the fact that their presence would be almost completely masked by the great abundance of terrestrial débris in all the deposits of the Arctic Ocean.

[1] *Loc. cit.*, p 541.

DESCRIPTION OF GENERA AND SPECIES.

TRIBE I.—RAPHIDIEÆ.

Amphora, Ehrenb.

The essential characters of the frustules of this genus are so difficult and complicated as to be but little understood. So much is this the case that Professor Arnott severely writes[1] that Dr Gregory having, in his pamphlet on the Diatoms of the Clyde, failed to indicate their distinguishing features, has thereby deprived his work of its claims to be considered scientific. These observations adequately prove the magnitude of the difficulties that exist, and indulgence may be claimed for any errors that occur in the treatment of so obscure and intricate a genus.

The general form of an Amphoran frustule may be taken to resemble that of a grain of coffee, but Dr Gregory's conception that the so-called frustule should be regarded as two perfect frustules that have become united apart from any process of conjugation cannot be entertained. If some species occur as very delicate cymbelloid forms, such as *Amphora coffeæformis*, Kg., this is attributable to the character of the connecting zone, which is extremely slender, and which may be destroyed by the slightest possible action of acids, even when diluted, or by fire.

Amphora speciosa, n. sp. (Plate XXVII. fig. 1.)

Elliptica sublinearis; apicibus rotundatis; valva introrsum inflata; striis punctulatis subradiantibus. Ad portum Thaiti.

This species would perhaps be identical with *Amphora oblonga*, Greg.,[2] were it not for the profile of the frustule, which is described by Gregory as "elliptic, rather broad," with "ends obtusely acuminate." The present form, however, is narrow, its margins are almost linear, and its extremities are rounded less sharply. The striation also differs in the two cases, being subradiate and evidently moniliform in *Amphora speciosa*, while in *Amphora oblonga* it is continuous. This new species, which is figured in its zonal aspects, was obtained at the port of Tahiti.

Amphora meneghiniana, n. sp. (Plate XXVII. fig. 16.)

Sublineariter elongata; apicibus rotundato-truncatis; medio late subinflata; striis transversis conspicuis subradiantibus. Ad portum Thaiti.

This magnificent new species was also first obtained at the port of Tahiti. It is of an

[1] *Quart. Journ. Microsc. Sci.*, vol. vi. p. 184, 1858.

[2] Diatoms of the Clyde, p. 43, pl. v. fig. 78.

elongated sublinear form, its centre is slightly inflated, and its extremities are roundly truncated. The continuous striæ form subradiating bars, and are easily discerned. The valves are slightly depressed at the centre.

It has been named in honour of the Italian naturalist Professor Giuseppe Meneghini, one of the earliest cultivators of the study of the Diatomaceæ.

Amphora scalaris, n. sp. (Plate XXVII. fig. 19.)

Oblonga, truncata, lineis dorsali et ventrali late biarcuatis, centrali medio angulariter inflexa; striis continuis raris transverse parallelis. Ad portum Jackson in Australia.

Of this remarkable form, which was collected at Port Jackson, Australia, only a single valve was observed. In this the dorsal line, like the ventral profile, is singularly biarcuate, while the raphe is angularly folded at the centre. The widely separated, transverse, equidistant, and continuous striæ are especially characteristic. The extremities are roundly truncated.

The specific name has been suggested by the appearance of the transverse striæ.

Amphora polyzonata, n. sp. (Plate XXVII. fig. 18.)

Forma lata, medio angulariter constricta; apicibus late rotundatis, truncatis: valvis introrsum inflexis; zona connectiva in plures fascias divisa; zona et valvis quadrato ordine punctulatis. Ad portum Thaiti.

In this species from Tahiti, just as in some *Naviculæ*, well-marked constrictions occur. Thus the valval involution is so strong and acute as to simulate the staurotic dilatation of a central nodule. A strongly biarcuated line forms a raphe, and the frustule, which is twice as long as broad, is widely and roundly truncated at the extremities. The connecting zone bears several longitudinal bands which, like the valves, have the granules arranged in a quadrate manner.

Plate XXVII. fig. 8, represents a two-lobed form which is angularly constricted, but far less deeply than *Amphora polyzonata*. The raphe is also strongly biarcuate, but the extremities are round and non-truncated. The length of the frustule is more than twice its breadth. The connecting zone bears longitudinal bands which, like the valves, are punctated. It may therefore be regarded as a mere variety of the former, the distinctions indicated being such as might result from differences in development. It was obtained at the port of Tahiti.

Amphora decora, n. sp. (Plate XXVII. fig. 14.)

Late inflata, elongata; apicibus obtusis subproductis; valvis medio inflexis; zona connectenti in fascias divisa, binis granulorum ordinibus et striis alternis insignita. Ad mare Philippinarum.

This beautiful little Amphora, from the mud of the Philippine Seas, has a widely inflated profile, and obtuse, slightly prolonged extremities. Each of the two valves,

which are very transparent, presents a central inflection which seems to indicate a depression in the raphe and in the plane of the valve. The connecting zone is distinguished by bearing linear bands, which are decorated in a special manner, being marked by striæ alternating with double files of granules.

The specific name has reference to this zonal sculpturing.

Amphora philippinica, n. sp. (Plate XXVII. fig. 2.)

Valvis ad dorsum arcte sinuato-constrictis, apicibus productis acutis; linea media recta ad polos vix deorsum inflata; striis transversis perspicuis punctulatis. In mari Philippinarum.

An acute constriction also occurs in this bi-lobed species from the Philippine Sea. Its apices are very prolonged, sharp, and slightly bent, and its transverse striæ are well defined, granulated, and subradiating.

By referring to A. Schmidt's Atlas[1] (Plate xxv. fig. 62) it may be observed that the present valve resembles the *Amphora coarctata* of Grunow, of which no description has been given. The latter, however, possesses capitated apices, and the striæ are thin, non-granulated, and not subradiating.

The specific name has reference to the locality in which it was found.

Amphora thaitiana, n. sp. (Plate XXVII. fig. 15.)

Elliptico-oblonga, polis rotundatis; valvis cymbiformibus, dorso late convexo, ventre inflato, apicibus obtusis; striis transversis validissimis per sulcos longitudinales interruptis. Ad portum Thaiti.

This type seems to be akin to the form represented in Plate xxviii. fig. 15 of the Atlas of A. Schmidt, which is a novelty if it be not the *Amphora egregia* of Ehrenberg. The present form, however, may be distinguished by its rounded extremities—in the form represented by Schmidt the ends are roundly truncated—and by the ornamentation of the valves. This consists of continuous costæ interrupted by longitudinal lines, while in Schmidt's frustule, and in *Amphora crassa* of Gregory,[2] which it resembles, the valves are distinguished by continuous costæ, and the dorsal areas by numerous longitudinal lines separated by rows of spots or small lines.

The distinction between the appearance of the extremities, apart from other structural differences, might have been explained by supposing that the frustules had attained different stages of development.

This new form is very abundant in the rich flora of Tahiti, and its specific name is intended to indicate this fact.

[1] Atlas der Diatomaceenkunde, in Verbindung mit der Herren Grundler, Grunow, Janisch, Weissflog und Witt, herausgegeben von Adolf Schmidt, 1875. See also a reproduction of the above about one-half the linear dimensions of the original, by C. Henry Kain, Camden, N.J., 1884.

[2] *Op. cit.* p. 52, pl. vi. figs. 94, 94*b*, 94*c*, and 94*d*.

Amphora staurophora, n. sp. (Plate XXVII. fig. 6.)

Valvis cymbiformibus, apicibus acutis; linea ventrali subrecta, dorsali convexa; nodulo medio in staurum ad marginem dilatato. Ad portum Thaiti.

The narrow stauros of this little cymbiform valve extends to the margin. The dorsal line is convex and presents a slight constriction at its junction with the stauros. The ventral line is straight, and the extremities are slightly inflexed. The apices of the valve are acutely rounded. The striation is very delicate and transverse.

The specific name has been derived from its long and well-defined stauros.

Amphora oceanica, n. sp. (Plate XXVII. fig. 20.)

Valvis deorsum subinflatis, introrsum late concavis; apicibus obtusis rotundatis; nodulo centrali lineam marginalem subattingente; striis tenuissimis transversis. Prope Sydney.

This new form, from the waters near Sydney, appears at first sight to be a variety of *Amphora obtusa*,[1] Greg., but to regard it thus would widen the limit of that species to too great an extent, so that the two forms cannot be included in the same category.

In *Amphora oceanica* the terminal nodules are not distinct, and the central nodule is in close proximity to the internal profile of the valve. The striation is singularly delicate and, as in *Amphora obtusa*, Greg., transverse.

Cymbella, Ag. Kg.

Two of the frustules described under this genus, and represented on Plate XXVII. figs. 5 and 13, namely, *Cymbella criophila* from the south of Heard Island, and *Cymbella marina* from the neighbourhood of Yedo, Japan, seem, at first sight, to belong to the genus Amphora. Since, however, the characteristic of that genus is to have a central marginal nodule, they cannot be included in that group, but must be classed as *Cymbellæ*, although no members belonging to the latter genus have been hitherto recorded as marine.

That an admixture of fresh-water and salt-water Diatoms should occur in marine gatherings is to be expected, however, when it is borne in mind that frustules of the former must often be carried into the sea by rivers. Thus *Asterionella formosa*,[2] Hass., and *Eunotia arcus*,[3] Ehrenb., which, like all other *Eunotiæ*, vegetates at an elevation of several hundred fêet above the level of the sea, have been detected in sea water; yet it cannot be doubted that *Cymbella marina* is a true pelagic form, and it is probable that *Cymbella criophila* has the same habitat. That representatives of this genus do live normally in sea water has indeed been clearly proved by me while working in the

[1] *Micr. Journ.*, vol. v. pl. i. fig. 34.

[2] *Micr. Journ.*, vol. viii. pl. vii. fig. 8; Microscopical Examination of the Water supplied to the Inhabitants of London, by Mr. Hassall, p. 10; Smith, Synopsis of the British Diatomaceæ, vol. ii. p. 81.

[3] *Abhandl. d. k. Akad. d. Wiss. Berlin*, 1840, p. 17; Rabenhorst, Süssw. Diat., fig. 6; Wigand in Hedwigia, vol. ii. p. 43, pl. vii. figs. 13 and 14.

canal of Trau, Dalmatia, for the purpose of studying the flora of the Adriatic. In this locality a perfect Cymbella was observed, in a preparation fresh from the sea, in a moving condition. Species have also been recorded in sand obtained by Gwyn Jeffreys, the well-known conchologist, in the vicinity of the Shetland Islands, although Professor Dickie, who first studied these gatherings, believed that the cymbelloid frustules were deposited on the bottom, after having been carried into the sea by rivers.

Cymbella criophila, n. sp. (Plate XXVII. fig. 5.)

Forma marina (?) elongata, sensim ad acutissimos apices declinans; linea dorsali convexa, ventrali vix convexiuscula; striis perspicuis punctulatis subradiantibus, ad centrum lineam mediam hinc inde inæqualiter non attingentibus. Ad meridiem insulæ Heard.

This interesting species, which was obtained to the south of Heard Island, has an extremely convex dorsal line, the ventral being only slightly convex. The frustule tapers at each end to a very sharp point. The striæ are well marked, and subradiating in disposition, each being formed by a series of very minute points. Those towards the middle of the frustule do not meet in the centre, where a smooth area which is notably larger on the more convex than on the less convex side of the valve is to be found.

This Antarctic Diatom may have been transported by icebergs into the sea, although the probability that it is truly marine must be borne in mind.

Cymbella marina, n. sp. (Plate XXVII. fig. 13.)

Forma marina, elongata; linea ventrali recta, dorsali late arcuata; apicibus rotundato-acutis; striis transversis parallelis, lineam mediam non attingentibus. Ad mare Japonicum, prope Yedo.

This species was obtained near Yedo in the Sea of Japan. The ventral line is straight, and the apices are rotundately acute. The valval striæ are parallel and terminate near the raphe, a non-striated nodule being left in the centre and being especially prominent on the side next the dorsal line.

That this form is truly marine cannot be questioned.

Cymbella pelagica, n. sp. (Plate XXVII. fig. 4.)

Mediocris; dorso turgido, ventre leniter convexo; linea media subcurvata; apicibus obtuso-truncatis, productis; striis moniliformibus subradiantibus.

The dorsal line, in this form, is greatly arcuate, the ventral being slightly convex. The apices are obtuse and somewhat prolonged, and the raphe is slightly curved. The striæ are subradiating and moniliform.

This Diatom, like the preceding, must be looked upon as a truly marine form, inasmuch as it has been observed in a moving condition under the microscope, and has been met with in more than one collection from the sea.

Mastogloia, Thwaites.

This genus was established by Thwaites in 1848, and is thus referred to by the late Dr L. Rabenhorst, who contributed so much to our knowledge of Cryptogams, in his Flora Europæa Algarum aquæ dulcis et submarinæ :—

"Frustula rectangulo-oblonga, aggregata vel solitaria, valvis naviculaceis transverse costatis, costis plerumque abbreviatis, nodulo centrali distincto."

Pritchard, in his History of Infusoria, defines the genus in the following words :—

"Frustules oblong, naviculoid, annulate, in a gelatinous mammillate cushion or frond; annuli loculated; loculi opening by foramina along the line of suture."

The chief difference between these two definitions consists in the fact that, in the former, the characteristic circumstance that the frustules are annulate and that the annulus is loculate, has not been referred to. It should, however, be noted that I have several times observed valves of *Mastogloia* entirely or partially devoid of such an annulus, so that this structure must be regarded as one of unessential significance.

Mastogloia thaitiana, n. sp. (Plate XXVI. fig. 11.)

Valvis elliptico-lanceolatis; apicibus productis, obtusis; striis decussatis lineam mediam simplicem attingentibus; annulo costato totum valvæ circuitum ambiente. Ad oras Thaiti.

This small form was obtained in an extraordinarily rich sounding made in the waters around Tahiti. The profile is precisely similar to that of *Mastogloia apiculata*,[1] W. Sm., but in the latter the striæ are transverse, while in the former they are decussate and oblique to the direction of the raphe.

The specific name of this Diatom has reference to the locality in which it was found.

Mastogloia kerguelenensis, n. sp. (Plate XV. fig. 11.)

Forma elliptica; apicibus cuneato-rotundatis; annulo loculato, medio latiori, hinc ad apices decrescente; valvæ area centralis ordine subquadrato granulata in sex fascias longitudinales dividitur; nodulus centralis in area lævi inscribitur. Ad insulam Kerguelen.

This singular and interesting species has an elliptical valve with cuneato-rotundate extremities. The loculate annulus is wide in the centre, but diminishes regularly and is very narrow at the ends of the frustule. The striation is transverse, subradiate, and formed by lines of granules disposed in a subquadrate manner. The central area, circumscribed by the loculate annulus, is divided by a raphe and by four symmetrically disposed longitudinal lines. The central nodule is represented by a smooth areola, which has an indistinct outline.

The specific name has reference to the locality in which the frustule was found.

[1] *Op. cit.* vol. ii. p. 65, pl. lxii. fig. 387.

Stauroneis, Ehrenb., Kg.

Although some authors, impelled by a desire of reducing the number of generic distinctions among Diatoms, have united into a single genus not only the *Pinnulariæ* and *Naviculæ* but also the *Stauroneides* and *Stauropteræ* of Ehrenberg, such a course cannot be regarded otherwise than as prejudicial to science. It is to be remarked, however, that the genera *Stauroneis* and *Stauroptera*, which do not contain a large number of species, may be amalgamated, so that, following the example of W. Smith, Pritchard, and others, any free navicular frustule with a middle line, terminal nodules, and a central stauros or transversely enlarged nodule, may be called a *Stauroneis*.

Stauroneis pacifica, n. sp. (Plate XX. fig. 9.)

Lanceolato-oblonga; apicibus obtusis; nodulo centrali in aream linearem ad marginem attingente; striis moniliformibus tenuissimis radiantibus, lineam mediam non attingentibus. In oceano Pacifico.

This frustule possesses a navicular lanceolate form, and is provided with obtuse prolonged extremities. The stauros extends to both margins. The striæ are very delicate granular, radiating and approximately parallel, they are obliquely disposed, and terminate before reaching the median line.

The species is named after the ocean in which it was first observed.

Stauroneis thaitiana, n. sp. (Plate XX. fig. 16.)

Parva, elliptico-lanceolata; apicibus cuneato-rotundatis; area transversa lineari brevi; striis tenuissimis transversis, parallelis. Ad portum Thaiti.

This small and elegant form from the rich collection obtained at the port of Tahiti possesses an elliptico-lanceolate outline, and is provided with roundly cuneate extremities. The central nodule expands transversely as a narrow linear area which stops before reaching the margin. The striæ are very fine, tranverse and parallel. The raphe is enclosed in a smooth narrow linear area.

Stauroneis salina, W. Sm., var. *c*, nov. (Plate XX. fig. 13.)

Probably this frustule must be regarded as a mere variety of the *Stauroneis salina* of W. Smith.[1] The following points of distinction between the typical species and the variety may however be noted:—(1.) The extremities of the latter are considerably more acute than those of the former; and (2.) the striæ, although erroneously represented coarser in the present species, are approximately of the same degree of fineness in both.

[1] *Op. cit.* vol. i. p. 60, pl. xix. fig. 188.

Since Rabenhorst[1] constituted a variety *b* for a form with obtuse apices, the present frustule has been indicated as variety *c* on account of the acuteness of its extremities.

Stauroneis brebissonii, n. sp. (Plate XV. fig. 4.)

Oblonga, medio late constricta; apicibus cuneato-obtusis, subproductis; striis ad nodulos radiantibus et medio aream lævem linquentibus.

This is one of the most curious forms of the genus *Stauroneis*. The valve is of oblong form, being narrower in the middle than at its extremities, and the two longitudinal lines are slightly sigmoid. The extremities are cuneato-obtuse and exhibit a slight constriction. The striæ are strongly radiating towards the centre and towards the nodules, and they terminate as in *Pinnularia divergens*,[2] W. Sm. They are absent in the centre of the valve, so that this area is very wide and is bounded only by the nearest striæ. The zonal side is sub-rectangular.

This species is named in honour of one of the earliest naturalists who prosecuted the study of Diatoms, Alphonse de Brebisson.

Stauroneis oblonga, Bail. (Plate XX. figs. 7 and 11.)

Different sizes of this species are here represented. On comparing the figures with Plate xlviii., fig. 16, of A. Schmidt's Atlas, one cannot fail to recognise the justice of the determination here arrived at, although the definition of the species, which is given by Pritchard,[3] does not at all agree with the present figures, which are of the form called "linear" by Bailey.

In this species it may often be observed that the striæ on one side touch the raphe, whilst on the other they stop short of it. This, however, cannot be compared with what takes place in *Alloioneis*, but is to be attributed to the fact that the raphe is raised and forms an oblique projection on one-half of the valve.

Stauroneis glacialis, n. sp. (Plate XXVII. fig. 11.)

Magna; valvis longitudinaliter late convexis, transverse arcte convexis; stauro lineari; striis dense transversis parallelis. In mari Antarctico.

This curious navicular frustule was collected in the Antarctic Ocean. It is of large size, and its valve is very convex in a longitudinal direction but much more so in a transverse, so that it cannot be entirely brought into focus at the same time. A median stauros stretches in a linear manner between the raphe and the margins. The striæ, which are very fine, are directed transversely.

[1] Rabenhorst, Flora Europæa Algarum Aquæ dulcis et submarinæ, p. 251. Here variety *b* is characterised as follows: "Forma sub polis leniter constricta, apicibus obtusis."

[2] Synopsis of the British Diatomaceæ, vol. i. p. 57, pl. xviii. fig. 177.

[3] This definition runs as follows: "Linear, with acute, cuneate ends, and oblique punctato-asperate striæ; stauros abbreviated, dilated outwards. . . . The size and markings of *Stauroptera aspera*, Ehrenb., but having its valves oblong, with parallel sides, and acute angular ends."—History of Infusoria, 4th edit. p. 914.

The specific name has reference to the occurrence of this frustule in the frozen Antarctic Ocean.

Plate XXVII. fig. 9, probably represents a variety of this species differing from the typical form in the following respects—(1.) the dimensions are much greater, (2.) the appearance is more swollen, and (3.) the striæ are relatively much finer. The arrangement of these striæ and the character of the stauros show its close affinity with *Stauroneis glacialis*, n. sp.; nevertheless, apart from its sublanceolate profile, its true varietal or specific character must at present remain somewhat doubtful.

Stauroneis pygmea, n. sp. (Plate XXIX. fig. 7.)

Parva, elongata-elliptica; apicibus rotundatis; area transversa sublineari marginem non attingente; striis moniliformibus subradiantibus. In mari Arafura.

This small form from the Arafura Sea possesses an elliptical outline and rounded extremities. The raphe is somewhat bent, and the stauros terminates in an irregular manner at a notable distance from the edge of the valve. The striæ are moniliform and radiating, and near the middle line they form a well-marked double somewhat irregular area.

Pinnularia, Ehrenb.

Nomenclature being nothing more than a means employed to facilitate the work of the naturalist in the description of the innumerable organic types with which he has to deal, Ehrenberg wisely divided the genus *Navicula*, Bory, which was already extremely rich in species, into two, and included under the generic name of *Pinnularia* those naviculoid forms whose valves were ornamented with pinnulæ or costæ and not by rows of granules. It is true, indeed, that some refuse to admit this distinction on the ground that the sculpturing of all naviculoid forms is ultimately reducible to granules, but, although some species, such as *Pinnularia peregrina*, Ehrenb., have been attributed to the genus *Navicula* because of the recognition of longitudinal lines which are made up of a dense series of oblong granules, all similar forms are not really granulated, there being many *Pinnulariæ*, which, when observed with the best object-glasses, with the most accurate manipulation of the light, and by the use of monochromatic illumination, have exhibited no granular structure.

Pinnularia raëana, n. sp. (Plate XV. fig. 3.)

Lanceolata; valvis spiraliter inflexis; linea media sigmoidea in area lævi lanceolata; costis circum radiantibus. Ad Zebu, ex insulis Philippinis.

This very singular and elegant species was discovered by Dr Rae in a collection brought from Zebu in the Philippine Islands. It possesses a very graceful lanceolate form. The central line or raphe is slightly sigmoid. The radiating continuous costæ do

not reach the raphe, but leave a smooth somewhat lanceolate area around the centre of the valve.

The specific name is given out of respect to its discoverer.

Pinnularia criophila, n. sp. (Plate XV. fig. 2.)

Anguste rhomboidea, transverse costata; costis lineam mediam attingentibus; apicibus rotundatis; valvis transverse convexis. Ad mare Antarcticum.

This form was brought from the glaciers of the Antarctic Ocean. The valve, as may be noted by comparing the figures representing the valval and zonal aspects, is not flat but transversely convex, so that its form somewhat resembles that of the diatom[1] shown in Plate xlvii. fig. 1 of Dr. A Schmidt's Atlas, although it is at once longer and narrower than the latter, which, moreover, is not transversely convex. It is rhomboidal in general outline, transversely costate—the costæ reaching the median line—and its apices are rounded.

Pinnularia sp. ? (Plate XV. fig. 1.)

We have here represented a bilobate form in which the striæ are continuous. The frustule is elegant in general appearance, elongated in shape, and provided with a wide central contraction. The two lobes into which it is thus divided are elliptical. The radiately disposed lateral costæ are interrupted by two wide longitudinal bands. Between these and the median raphe there is a long sublinear and elliptical area on which, towards the middle line, the terminations of the costæ may be traced. The central nodule is oval, its long axis being directed transversely. The fact that navicular bilobate frustules are apt to present a difference of structure according to the stage of development at which they have arrived renders it difficult to decide on the true taxonomic value of this type, hence it has been provisionally recorded as an undetermined species of *Pinnularia*.

Navicula, Bory.

The examination of the navicular forms in the Challenger collections has been the means of still further augmenting this already extensive genus. In Pritchard's History of the Infusoria 303 species have been described, in A. Schmidt's Atlas of the Diatomaceæ—a publication which unfortunately was interrupted—more than 200 forms are figured, while in Habirshaw's Catalogue of the Diatomaceæ a still greater number of specific names have been registered. It is true, indeed, that in both of these lists forms possessing continuous striæ, upon which characteristic Ehrenberg con-

[1] With respect to this frustule Schmidt says: "1. G. v. Mexico, 2. Spitzbergen, 3. St. George's River, 4. Yokohama, Formen, welche weder mit *N.* (*i.e.*, *Navicula*) *directa* noch mit *N. longa* verbunden werden können."—*Loc. cit.*, Explanation of Plate xlvii.

stituted the genus *Pinnularia*, are included, but apart from this the species already recorded as belonging to the genus *Navicula*, properly so called, are so numerous as to tend to bring about confusion in the science, and to render difficult if not distasteful the work of one who introduces new types. Yet such a course is inevitable when a minute examination of marine micro-organisms is made, and it becomes of the greatest importance to subdivide the larger genera, and above all the genus *Navicula*, distinguishing in them groups based on some common and more salient characteristics, in order to make it possible to remember the different forms. Hence, although recognising the weight of the authority of Kützing and Brebisson, who join together the genera *Navicula* and *Pinnularia* because some of the latter are found to be granulated, and because there is perhaps no specimen the costules of which, according to these distinguished naturalists, may not be resolved into points, still, as this assertion has not yet been proved, I am unable, resting on the authority of W. Smith and Rabenhorst, to adopt their arrangement. Still less can I agree with those who join the genus *Stauroneis* to that of *Navicula*, although both are naviculoid, because, in that case, many other genera which are likewise constituted on navicular forms would have to be abandoned.

One of the most extensive group of the genus *Navicula* is that in which the valves are more or less contracted in the middle and which Ehrenberg designated by the name of *Diploneis*.[1] In this section the species, on account of their number, are the most difficult to define.

Navicula abnormis (?), n. sp. (Plate XXVIII. fig. 19.)

Panduriformis; apicibus cuneato-rotundatis; striis subradiantibus moniliformibus; nodulo centrali quadrato; area centrali medio subconstricta.

This singular frustule is remarkable on account of the different magnitudes of the two halves of its valves, and should probably be regarded as an anomalous and monstrous form were it not that several specimens have been found in the same collection. If it should ultimately prove to be a monstrous frustule it will be especially liable to sterility, and although a few generations may come and go its long survival in the struggle for existence cannot be expected; it may, however, for the present receive a specific name. Its shape is panduriform, its apices cuneately rounded, and its moniliform striæ are subradiating. It possesses a quadrate central nodule, and the central area is slightly constricted at the middle.

Navicula thaitiana, n. sp. (Plate XX. fig. 5.)

Bilobata, arcte constricta; lobis subcordatis; apicibus cuneato acutis; striis moniliformibus radiantibus, medio evanescentibus; linea media tenui, nodulis parvis. Ad portum Thaiti.

[1] Pritchard, *loc. cit.*, pp. 892 *et seq.*

This elegant naviculoid frustule, found in the interesting collection from the port of Tahiti, recalls, when viewed in profile, the *Navicula proserpinæ* of Ehrenberg,[1] which is identical with the *Navicula kützingii*[2] of Grunow. Its two lobes are subcordate and the extremities are cuneato-acute. The nodule, which in Ehrenberg and Grunow's type is large and quadrate, is here very small, nor does the frustule present such longitudinal bands as separate the striæ of the *Navicula proserpinæ* and *Navicula kützingii*.

In *Navicula thaitiana* the radiating moniliform striæ gradually become less visible towards the centre.

Navicula entomon, Ehrenb., var. *thaitiana*, nov. (Plate XX. fig. 17.)

We have here represented a frustule which is probably only a variety of *Navicula entomon*,[3] Ehrenb. Its centre is more contracted than that of the typical species, and its two lobes present an elegant elliptical profile. Both forms possess lines of slightly subradiating but manifest granules, which differ from those of all other bi-lobed navicular frustules. The present diatom has a very strong round central nodule, but this characteristic, taken by itself, cannot be regarded as sufficient to constitute a species.

Navicula entomon, Ehrenb., var. (?) (Plate XX. fig. 10.)

This frustule can scarcely be said to be sinuately constricted, but its raphe, which is slightly bent when viewed in profile, really possesses a double curvature and is flanked on both sides by a band of granules.

With reference to these peculiarities it is to be remarked that they are probably merely developmental stages in the life-history of the species. Thus in the younger frustule the raphe may be straight instead of bi-curved, while in embryonic phases the granules are not well defined but become more and more marked as age advances.

Navicula grunowii, Rabenh. (?) (Plate XV. fig. 9.)

The present figure represents an elegant *Navicula* possessing a valve which is almost linear in profile. On comparison with Plate lxx. of Schmidt's Atlas it is found to coincide almost exactly in its characteristics with *Navicula pristiophora*, Janisch, and with *Navicula grunowii*, Rabenh.[4] It may accordingly be regarded as intermediate between

[1] = *Diploneis proserpinæ*, Ehrenb., *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1858, p. 14; see Pritchard, *loc. cit.*, p. 893.

[2] This form is shown in Plate xiii. fig. 24 of Schmidt's Atlas; see also *Verhandl. d. k. k. zool.-bot. Gesellsch. in Wien*, 1860, p. 532, T. i. fig. 15.

[3] Established by Ehrenberg in 1840; = *Pinnularia entomon*, Ehrenb. (Verb. T. i. 1, F. 3 *et* 4; Kütz., Bac., p. 100, T. xxviii. fig. 74); and = *Diploneis entomon*, Ehrenb. Mikrogeol., T. xix. f. 30; see also Pritchard, *loc. cit.*, p. 893.

[4] See Schmidt's Atlas, pl. lxx. figs. 72 and 73; and Rabenhorst's Flora Europæa Algarum, sect. 1, p. 203, Lipsiæ, 1864.

the forms just named, being less sinuately incurved than the former and somewhat more so than the latter. All three possess transversely disposed continuous striæ which are parallel to each other in the middle, but are directed in a radiating manner at the extremities, and in all the striæ are interrupted by two longitudinal furrows, while their central extremities are placed in close proximity to the raphe. Such considerations point to the conclusion that we have here a form which is very probably identical with the *Navicula grunowii* of Rabenhorst.

Navicula janischii, n. sp. (Plate XXX. fig. 5.)

Biloba, profunde constricta, lobis cuneato-subcordatis; structura dense et inordinate granulata; plicis a margine radiantibus, hinc evanescentibus. Ad insulas Bermudas.

This frustule, from the neighbourhood of the Bermudas, possesses an exceedingly elegant, bilobed form. The lobes are subcordate and cuneiform, and the margins are marked by a row of well-defined dots, while the surface is irregularly granulated and carries radiating lines which proceed inwards from the periphery but become indistinct and disappear before reaching the raphe.

It bears a considerable resemblance to a frustule from Samoa which occurs in a superb preparation by Möller, but in the latter the middle plica is absent and the granulations of the surface are much less marked. It is also somewhat similar to the *Navicula jamaicensis* described by Greville, but in the Grevillean species the points or granules are disposed regularly instead of being agglomerated without order.

This new species is named in honour of Mr Charles Janisch the Diatomist.

Navicula bullata, Norman, var. *carinata*, nov. (Plate XXVIII. fig. 7.)

The specimen here represented is evidently closely related to the *Navicula bullata*[1] of Norman. This is indicated by its elliptical form, its obtuse apices, and by the radiately disposed rows of granules, which are interrupted by two distinct bands upon which a small number of large rounded dots occur.

The apices of the frustule are clearly hollowed and the valves are longitudinally plicated; the longitudinal bands do not present any constriction in the centre, and the granules are much less numerous than those of *Navicula bullata*.

Navicula bullata, Norman, var. *obtusa*, nov. (Plate XXVIII. fig. 10.)

This frustule is elliptico-rhomboidal and not simply elliptical like that established by Norman, nor, and this is a matter of greater importance, are the apices of the former in any way elongated or sub-produced, but are merely rounded. The significance of this fact becomes more apparent when it is borne in mind that, among navicular Diatoms in

[1] *Micr. Journ.*, 1861, p. 8, pl. ii. fig. 7.

particular, the shape of the apex is constant in each type. As in the variety last mentioned there are two smooth longitudinal areas, but these are slightly constricted in the middle, where they are ornamented by a few prominent rounded dots.

The specific name is taken from the character of the apex.

Navicula bullata, Norman, var. *rhomboidea*, nov. (Plate XXX. fig. 7.)

This bullate navicular frustule is subrhomboidal in shape, and the prolonged apices of the valves are rounded. The valve is plicated by several longitudinal furrows, but, although this characteristic is exceedingly distinct, the form can be regarded only as an interesting variety of *Navicula bullata*. As in the previous varieties there are a few well-marked dots at the centre of the smooth longitudinal areas which are here plano-convex in outline and situated around the central area of the valves. This specimen was gathered at Zebu.

Navicula brasiliensis, Grun. (Plate XX. figs. 1 and 3.)

We have here represented the typical form of the *Navicula brasiliensis* of Grunow,[1] but the valves cannot be said to be "oval," nor the apices "very acute," as that author, whose figure agrees entirely with the present one, has declared. In Grunow's frustule, moreover, the central nodule is "large and subquadrate," but in the form now being considered the raphe is interrupted by a subrotund areola.

This form was obtained at the port of Tahiti.

Plate XX. fig. 3, represents a very small navicular frustule from the same locality in which the central areola is round. It accordingly corresponds more exactly with the frustule described by Grunow.

Navicula mammalis, n. sp. (Plate XX. fig. 2.)

Elliptico-lanceolata; apicibus mammiformibus; lineis granulatis radiantibus, ad centrum cessantibus. Ad mare Philippinarum.

This form was obtained from a sounding made in the neighbourhood of the Philippine Islands. Its shape is elliptico-lanceolate, and it possesses mammiform apices. The radiating granular striæ extend from the periphery towards the median raphe, which, however, they do not reach. The central nodule is surrounded by a smooth areola, which is marked only by two arched shadows.

The name of this species is derived from the character of its extremities.

Navicula subrhomboidea, n. sp. (Plate XX. fig. 4.)

Parva, lanceolato-rhomboidea; apicibus cuneatis; striis punctulatis, transversis, lineam mediam attingentibus. In mari Pacifico.

[1] *Verhandl. d. k. k. zool.-bot. Gesellsch. in Wien*, 1863, T. xiv. fig. 10.

This species, which was obtained from the bottom of the Pacific Ocean, possesses a lanceolate-subrhomboidal outline with wedge-shaped extremities. The surface is covered with dense transverse and subradiating rows of granules that touch the middle line which is interrupted at the centre.

The specific name has reference to its subrhomboidal outline.

Navicula oxeia, n. sp. (Plate XX. fig. 8.)

Parva, lanceolata; apicibus acutis; striis transversis, lineam mediam attingentibus. Ad mare Japonicum.

This small navicular lanceolate frustule was gathered in the Sea of Japan. Its extremities are notably acute, and its fine transverse striæ touch the median raphe.

These characters correspond with those of the type represented in Schmidt's Atlas, Plate xlix. fig. 17, which was obtained from Samoa, and of which the accurate determination was left in doubt. On the other hand, the frustules delineated in figs. 15, 16 and 18 of the same plate evidently belong to a different species, and it is by no means easy to understand the grounds upon which Schmidt grouped the four forms together.[1]

The Samoan frustule, as well as that now recorded from the Sea of Japan, may be designated *Navicula oxeia* on account of the singularly acute character of the extremities.

Navicula zanzibarica, Grev., var. *zebuana*, nov. (Plate XXVIII. fig. 8.)

The present specimen does not fully coincide with the *Navicula zanzibarica* of Greville. On making an accurate comparison with the figure given by Greville,[2] as well as with that found in Schmidt's Atlas (Plate ii. fig. 3), it may be observed that, while in Greville's species the striæ are divided into two series by a smooth longitudinal band, in the present frustule an indication of the striæ can be recognised between the band and the raphe by the presence of some minute granules. Moreover, in the latter the two spots, one of which occurs on each side of the central nodule, are tolerably regular, and show in the centre a lineal band formed by stronger granules, but in the former the bands are curved in order to adapt themselves to the form of the granulated side of the valve. The present frustule may accordingly be regarded as a variety, and named, from its origin, *zebuana*.

Navicula parallela, n. sp. (Plate XXVIII. fig. 12.)

Valvis lineariter elongatis; apicibus cuneato-rotundatis; striis tenuissimis, parallelis, transversis; areola lævi ad centrum. In portu Thaiti.

[1] In his explanation of the plate Schmidt explains his figures as follows:—
"15. Pudasjärri, 17. Norrland, *N.* (*i.e.*, Navicula) *bisulcata*, Lagerstedt.
16. Sing-Sing, Hudson R., *N. firma* var. *subundulata*, Grun.
18. Sodanskylæ, nach Grunow Mittelform zwischen *N. firma* u. *N. bisulcata*."

[2] *Trans. Micros. Soc.*, vol. xiv., 1866, pl. xii. fig. 22.

This very delicate form, from the port of Tahiti, possesses extremely delicate striæ. The valve is linear in form, and its extremities are cuneately rounded and sometimes slightly protracted. The specific name has reference to the parallel disposition of the striæ.

Navicula, sp. (?) (Plate XXVIII. fig. 13.)

We have here represented another naviculoid very finely fluted frustule from the same collection, and remarkable from the fact that its raphe is bent. This appearance may have resulted during the final stages of development, when growth in the centre of the valve may have continued after that at the circumference had ceased, thereby producing the undulating raphe referred to.

Plate XXVIII. fig. 17, represents a curious lanceolate *Navicula*, provided with a broad rounded median region which tapers towards the narrow obtuse extremities. The central nodule is large and round, but the striæ are almost invisible in Canada-balsam preparations. Since all its characteristics could not be determined, its specific value must at present remain undecided.

In Plate XXVIII. fig. 15, a naviculoid frustule from the collection made at the port of Tahiti is delineated in its zonal aspect. From this point of view it possesses a biconvex outline, the raphe, however, is low at the centre of the valves.

The magnificent frustule represented on Plate XXVIII. fig. 9, differs from *Navicula spectabilis*, Grev., in the elliptico-rhomboidal form of its valve—a distinction which, however, cannot be regarded as of sufficient importance to justify the establishment of a new species for this form.

Navicula decipiens, n. sp. (Plate XXVII. fig. 17.)

Magna, late lanceolata, apicibus rotundatis; striis transversis subtilissimis; nodulo centrali minimo. In mari Philippinarum.

This frustule may at first sight be regarded as belonging to the genus *Amphora*, since, like the latter, it presents in the middle region two small noduli. It is to be noted, however, that the two noduli are not at the same level, while the two peripheral lines belong to different valves which are closely united by a connecting zone.

The form of the frustule and the very minute transverse striation may also lead the observer to regard it as being identical with *Navicula ostrearia*,[1] Kg., but the size of the different specimens that may be observed, and the extreme smallness of the central nodule, oppose this view. Moreover, the proximity of the two valves argue its distinct specific character. From the apparent agreement with the genus *Amphora* the specific name *decipiens* has been chosen for this form.

[1] Kützing, Species Algarum, p. 77.

Navicula (?) jejuna, A. S. (Plate XX. fig. 12.)

We have here represented a frustule whose characteristics almost perfectly coincide with those of the Java form figured in Schmidt's Atlas, Plate xlvi. fig. 76. In the latter the extremities, which are somewhat prolonged, are cuneately rotundate, while the ribs are wide and transversely disposed in the middle but subradiating at the ends. In the present case the outline is that of an ellipse of very great eccentricity, yet both forms must be regarded as being specifically identical.

Whether the generic name of *Pinnularia* or *Navicula* should be adopted must for the present remain uncertain.

Navicula (?) jejuna, A. S., var. nov. (Plate XXVIII. fig. 11.)

The present figure represents a variety in which the shape of the valve and the character of the striation for the most part agree with the typical species. The difference observable in the central nodule may be explained by the fact that the nodule and raphe are somewhat more raised than usual, and are accordingly seen in a lateral position. It may also be distinguished from the typical frustule figured by A. Schmidt when viewed in profile, being somewhat broader in proportion to its length.

Navicula kerguelenensis, n. sp. (Plate XXVIII. fig. 16.)

Parva, elliptica; apicibus cuneato-rotundatis; striis punctulatis subradiantibus; areola media subelliptica transversa. Ad insulam Kerguelen.

This small naviculoid frustule was found in a collection of Diatoms from a sounding made near the island of Kerguelen. Its form is elliptical, and its extremities are cuneately rotundate. The striæ are fine and subradiating, while a subelliptical transverse areola occupies the centre. No type hitherto recorded agrees with this form in its leading characteristics, which has accordingly received a specific name indicative of the locality in which it was obtained.

Navicula lyra, Ehrenb., var. *signata*, A. S. (Plate XXX. fig. 13.)

This figure represents an elliptical and elongated naviculoid frustule, in which the form of the two bands that separate the striated regions indicates an agreement with the *Navicula lyra*[1] of Ehrenberg. Its greatly elongated and hollowed valves, however, render it necessary to regard it as a variety of Ehrenberg's typical species. This view has already been adopted in the case of an identical form by A. Schmidt,[2] who has named it *Navicula lyra*, Ehrenb., var. *signata*, A. S. The present frustule was obtained in the neighbourhood of the Philippine Islands.

[1] Ehrenberg, Verb. p. 131, pl. i. 1, fig. 9; Gregory, *op. cit.*, p. 13, pl. i. fig. 13; Janisch et Rabenhorst, Hondur., pl. iii. fig. 7, &c.

[2] Schmidt's Atlas, pl. ii. fig. 4.

Navicula mirabilis, n. sp. (Plate XXX. fig. 10.)

Rhomboidea-elliptica; striis binatis moniliformibus radiantibus ter utrinque interruptis; nodulo centrali subrotundo. Ad Zebu, ad insulas Philippinas.

This magnificent elliptical form seems at first sight to be identical with *Navicula smithii*,[1] Breb., which, on the whole, resembles it in its general characteristics. In the latter, however, each half of the valve is divided into two unequal parts by a single longitudinal line, whilst in the present case there are three longitudinal lines on each side of the raphe and cutting the transverse and subradiating granulated striæ. Moreover, the shape of the present valve is rhomboido-elliptical rather than elliptical, so that it must be viewed as specifically distinct from *Navicula smithii*. *Navicula mirabilis* was obtained at Zebu near the Philippine Islands.

Navicula cyclophora, n. sp. (Plate XXVIII. fig. 18.)

Minima, elliptico-subinflata; apicibus obtuso-rotundatis; striis radiantibus; cyclo laterali ad nodulum centralem. In mari Antarctico.

This form was gathered between Kerguelen and Heard Islands. It is remarkable in having on one side of the central nodule a very small circle, which is not due to any casual superposition, but is a part of the valve itself. A similar phenomenon occurs in *Cocconeis cyclophora* as made known by Grunow.[2]

In a most interesting collection from Bahia given to me by Mr Weissflog I have observed another species of *Cocconeis* with a lateral mark, and two years ago in the Gulf of Naples a third form was recorded as possessing the same peculiarity. Hence, instead of being viewed as of specific value, this character may be regarded as being analogous to the craticular condition of some *Naviculæ*. This view is confirmed by a micro-photograph of a *Navicula lyra*, Ehrenb., which has been furnished by Mr Weissflog, inasmuch as the valve, which has its centre marked by small circles, is distinguished by possessing a lateral hyaline area.

Navicula, sp. (?) (Plate XX. fig. 6.)

In this figure there is delineated a small naviculoid frustule which differs slightly from the preceding in the form, direction, and perhaps also in the fineness of the striæ. Moreover, instead of the small lateral circle found in *Navicula cyclophora*, n. sp., it possesses a non-striated space on one side of the central nodule. Both forms, however, agree in having the two sides of the valve unsymmetrical. Its specific value must at present remain uncertain.

[1] See note on this species in Smith's Synopsis of the British Diatomaceæ, vol. ii. p. 92; Pritchard, *loc. cit.* p. 898.

[2] Dr. H. van Heurck, Synopsis des Diatomées de Belgique, pl. xxx. figs. 24 and 25.

Navicula, sp. (?) (Plate XXVII. figs. 3 and 7.)

We have here delineated two other navicular forms, both being represented in their zonal aspects, probably owing to the fact that they possess very narrow valves. Both possess a similar striation, but while the profile in fig. 3 is curvilinear, that in fig. 7 is straight. This difference may be explained by saying that in fig. 3 the zonal side is seen somewhat obliquely.

The perfect resemblance of the striation and the identity of their locality—both being found to the south of Heard Island—render it very probable that both forms represent the same species, or at most that one is a variety of the other.

Although the minute transverse striation might point to an identity between these forms and *Navicula liber*,[1] Sm., such an opinion, on closer examination, cannot be entertained, the striation, which is characteristic of the connecting zones in the present frustules, differing from the corresponding sculpturing in Smith's species.

Navicula, sp. (?) (Plate XXVII. fig. 10.)

This figure represents a single valve which must belong to another species of *Navicula*. Its general outline is plano-convex, and its extremities well defined and bluntly recurved. The longitudinal axis exceeds two and a half millimetres in length. It is transversely granulated, save in the narrow areola which surrounds the central nodule. The probability that this is a sporangial frustule may be borne in mind.

No navicular form hitherto recorded possesses so large a size as the present one, whose specific designation must, however, remain undecided till further observations have been made.

Alloioneis, Schumann.

The late Professor Schumann, recognising the advisability of separating from the extensive genus *Navicula* all those forms that possess distinctive characters in common, established the genus *Alloioneis* for frustules which, while they were symmetrical in their external profile, had long striæ on one side of the raphe and short on the other.

This new genus, which has been accepted, amongst others, by the Swedish micrographer Professor P. T. Cleve, has been defined by Schumann[2] as follows:—"Navicula, ab altera lineæ longitudinalis parte pinnulis longis, ab altera parte pinnulis brevibus prædita, sectione transversa rhomboidea."

Alloioneis antillarum, Cl. et Grun., var. nov. (Plate XV. fig. 5; Plate XX. fig. 14; Plate XXVIII. fig. 14.)

Plate XX. fig. 14, represents a diatom which resembles the species established by Cleve under the name of *Alloioneis antillarum*, Cl. et Grun.[3] It may be noted, however,

[1] Smith, *op. cit.*, vol. i. p. 48, pl. xvi. fig. 133.

[2] Die Diat. d. H. Tatra, p. 73, 1867.

[3] Diatoms from the West Indian Archipelago, by P. T. Cleve, p. 8, pl. i. fig. 11, 1878, published in *Bihang k. Svenska Vet. Akad. Handl.*, Band V., No. 8.

that the present frustule differs from Cleve's species in the fact that the curvature of the middle line is much less—a distinction which is probably due to the fact that we have to deal with different stages of development in the two cases, and one which is not of great importance.

This form occurs pretty frequently in the sea around the Philippine Islands as well as in the Sea of Japan.

The form represented in Plate XV. fig. 5, is also closely related to the same species. It possesses, however, a somewhat rhomboidal profile and the extremities are more obtuse, the raphe being at the same time more excentric. Notwithstanding these differences, it must be regarded as merely a varietal frustule.

Plate XXVIII. fig. 14, represents another variety of *Alloioneis antillarum*, Cl. et Grun., which differs from the latter only in the much greater dimensions of the frustule and in the proportion between the longitudinal and transverse axes.

Alloioneis japonica, n. sp. (Plate XX. fig. 12, *bis.*)

Linearis elongata; apicibus cuneato-rotundatis; striis laxis, transversis, ad apices subradiantibus, huc lineam mediam attingentibus, illuc brevioribus et lævem aream linquentibus. Ad mare Japonicum.

This curious navicular form was found in mud procured from a sounding of 335 fathoms in the Sea of Japan. It possesses a long narrow elliptical form and terminates in two cuneato-acute extremities. The striæ, which on one side touch the raphe, do not reach it on the other side, and near the central nodule they leave a well-marked smooth area.

Pleurosigma, W. Smith.

The genus *Pleurosigma* is perhaps the most remarkable among the navicular Diatoms. The surfaces of the valves are adorned with very minute granules, and this fact, as is well known, is often made use of in testing the quality of objectives for microscopes.

The genus includes all those navicular forms which possess a granulated surface, and whose valves, or at least central raphes, are curved in a sigmoid manner. The name *Gyrosigma* was that first given by Hassall[1] to such forms, but the word *Pleurosigma*, which was introduced by W. Smith, has now been universally adopted, being more in conformity with the rules of nomenclature, and also because of the accuracy maintained by that observer in his revision of the species which belong to this group.

The valves of all species of the genus are covered with very minute equal granules arranged in a quadrate or in a decussate quincuncial order, and upon these characteristics Smith based his general system.

[1] Pritchard, *op. cit.*, pp. 915, 916.

The zonal side of the frustules is so much narrower than the valval as to render it almost impossible to meet with an individual that shows anything more than the plane of the valve. This is generally elevated, and, when seen with the binocular stereoscopic microscope of Nachet, shows itself in the form of an extremely depressed pyramid with a very extended basis, so as to cause some doubt in the case of species in which the raphe divides the extremities of the valve unequally, as in *Pleurosigma formosum*, W. Sm., *Pleurosigma decorum*, W. Sm., *Pleurosigma balticum*, W. Sm., &c., whether this appearance may not be the effect of a difference in obliquity at that point of the extreme sides of the pyramid.

Pleurosigma elegantissimum, n. sp. (Plate XXVIII. fig. 1.)

Valvis gracillime lanceolatis, rotundato-acutis; linea centrali excentrica medio inflexa; striis obliquis delicatissimis. Ad mare Japonicum.

This frustule was found in a sounding made near Yedo in the Sea of Japan. The striæ, which are very delicate, are arranged in a decussate manner. The form of the valve is slightly lanceolate, and the extremities are acute. The profile reminds the observer of the *Pleurosigma delicatulum* of W. Smith,[1] but it may be at once distinguished from the latter by the fact that the raphe divides unequally not only the extremities but also the general surface of the valve. Moreover, towards the central nodule the raphe of *Pleurosigma elegantissimum* is depressed so that the sigmoid line appears broken.

From such considerations the specific value of this form cannot be doubted.

Pleurosigma naviculaceum, Breb., var. nov. (Plate XXVIII. fig. 3.)

We have here represented a very minute *Pleurosigma* which was found in the Arafura Sea, where many other very interesting forms have been obtained. It is remarkable on account of its lanceolate profile and its greatly sigmoid raphe, which divides the two halves of the valve unequally. The central nodule is oval and very large, and in the closest proximity to this on both sides there is a well-defined smooth areola. The extremities are somewhat lengthened and rounded, and slightly recurved in a sigmoid manner.

Similar characteristics are found in *Pleurosigma naviculaceum*,[2] Breb., with the exception of the double indistinct areola near the central nodule.

Pleurosigma speciosum, W. Sm., var. nov. (Plate XXVIII. fig. 2.)

This figure shows another linear *Pleurosigma*, which was obtained in a sounding taken at the port of Tahiti. The striæ, which are arranged in a decussate manner, are

[1] W. Smith, *op. cit.*, vol. i. p. 64, pl. xxi. fig. 202.

[2] Brébisson, Diat. de Cherbourg, p. 17, fig. 7; = (1.) *Gyrosigma transversale*, Microg. Dictionary, 1854, pl. xi. figs. 37 and 38; (2.) *Pleurosigma transversale*, W. Smith, *op. cit.*, vol. ii. p. 96.

not very minute. The central line or raphe is throughout the greater part of its course straight but curves near the extremities of the valve, so that the surface of the latter is divided into two equal parts while the raphe runs obliquely across it.

The *Pleurosigma speciosum* of W. Smith[1] agrees with the present form in every respect except with regard to the profile of the valve, which, instead of being linear, is in the former linear-lanceolate. Hence the Tahitian frustule has been regarded as a variety of Smith's species.

Pleurosigma arafurense, n. sp. (Plate XXVIII. fig. 5.)

E minimis, lanceolata, vix sigmoidea; apicibus obtusis; linea media excentrica; nodulo centrali grandiusculo, quadrato; striis decussatis tenuissimis. In mari Arafura.

This very minute species, from the Arafura Sea, is provided with excessively delicate striæ. It is remarkable on account of the size and subquadrate form of the central nodule as well as the very slight sigmoid curve of the profile of the valve. The median raphe is central and the extremities are obtusely rounded.

The specific name has reference to the locality from which it has first been recorded.

Pleurosigma thaitiense, n. sp. (Plate XXVIII. fig. 4.)

Valvis lanceolatis, gradatim ad apices acuto-rotundatos terminantibus, et moderate curvatis; raphe centrali ad apices submarginali; striis decussatis vix perspicuis. In portu Thaiti.

This very elegant frustule possesses a lanceolate sigmoidal form and acutely rounded extremities. The flexion is moderate, and the central raphe becomes decidedly excentric towards the ends. The granulation is very delicate and decussate.

Pleurosigma smithianum, n. sp. (Plate XXVIII. fig. 6.)

Valvis lanceolatis, acutis, aduncis; raphe sigmoideo, ad centrum oblique transverso, dein submarginali. Ad portum Thaiti.

In the collection which contained *Pleurosigma thaitiense*, n. sp., from the port of Tahiti, the present frustule was often observed. The disposition of the raphe is particularly noteworthy, remaining submarginal at the two extremities, then closely following the outline of the valve, and finally abruptly crossing it near the centre in an elegant curve. The extremities of the valve are acute and somewhat hooked. This form is extremely characteristic and very easy to determine.

Pleurosigma japonicum, n. sp. (Plate XXIX. fig. 14.)

Minimum, sigmoideo-lanceolatum; linea media apices cuneato-obtusos inæqualiter dividente; grandiusculorum punctulorum lineis decussatis. Ad mare Japonicum.

[1] W. Smith, *op. cit.*, vol. i. p. 63, pl. xx. fig. 197.

This form is remarkable on account of its small size and the large granulations that occur on its surface. In profile it is slightly sigmoid, the raphe being much more so, so that the extremities are unequally divided by the raphe. The longitudinal axis is almost four times as long as the transverse axis.

This type is not uncommon in the Sea of Japan, and its specific name has reference to this circumstance.

Toxonidea, Donkin.

Under this head are comprised a few navicular forms which, whilst they present a granulation identical with that of *Pleurosigma*, have the extremities of their valves more or less curved in the same direction, the middle line being, at the same time, decidedly arcuate.

Toxonidea challengeriensis, n. sp. (Plate XXVI. fig. 15.)

Forma gracillima lanceolata; apicibus elliptice inflatis et symmetrice curvatis; raphe medio subcentrali ad apices excentrico; striis densissime decussatis. Ad portum Thaiti.

Amongst the many interesting types which were obtained from the washings of sand brought from the port of Tahiti, and from no great depth, the singular navicular form now being considered was observed. It possesses a very long and slender lanceolate form, having the two extremities strongly bent in the same direction. The raphe remains almost central throughout the greater part of the valve, but becomes eccentric near the more attenuated extremities.

Toxonidea challengeriensis, n. sp., var. nov. (Plate XXVI. fig. 14.)

We have here represented a small but interesting form first observed by Cavaliere Alessandro Garbi of Florence, among some algæ from the Mediterranean. Although differing sensibly in size, no distinction between the striation of the Tahitian and Mediterranean specimens was observed, so that the latter has been regarded as a variety of the former. It was first recorded by Garbi in the Tirreno Sea.

Amphiprora, Ehrenb., Kg.

Of all the genera of Diatoms that of *Amphiprora* is one of the most difficult to understand. Pritchard defines it as follows:—"Frustules free, simple in front view, constricted at the middle; valves convex, with a longitudinal wing, and central and terminal nodules; striæ, when present, transverse." I am of opinion that the frustule is naviculoid, and that on the axis, and as an emanation from the axis or from the raphe, bilobate wings appear.

Those species which, like *Amphiprora alata*, Ehrenb., Kg., are bent spirally, are the most difficult to understand, being very frequently seen with a cone-shaped profile. Those that are not spirally bent have the zonal side more or less panduriform owing to a central constriction resulting from the bilobate form of the wings. The genus may, accordingly, be conveniently divided into two sections, one comprising the non-spiral and the other the spirally bent forms.

Amphiprora plicata, Greg., var. *japonica*, nov. (Plate XXX. fig. 8.)

A small specimen from the Sea of Japan is here represented. It greatly resembles *Amphiprora plicata*,[1] Greg., having a panduriform profile owing to the existence of a deep central constriction. In both, too, the extremities are rounded and the connecting zone is marked by longitudinal lines or folds. In the species determined by Gregory, however, no noteworthy marks occur at the lines of junction between the wings and the valves, whereas in the frustule from the Sea of Japan more salient points occur at intervals of about four striæ. These puncta are probably formed by a thickening of the striæ, so that a kind of longitudinal keel somewhat similar to that which is found in the genus *Nitzschia* is the result. Although this characteristic is well marked it cannot be viewed as of specific importance, so that the Japanese form must be looked upon as a variety of Gregory's species belonging to the non-spiral section of the genus.

Amphiprora fimbriata, n. sp. (Plate XVII. fig. 15.)

Spiralis, oblongo-elliptica; apicibus late rotundatis; ala vel carina undulata; striis imperspicuis. In mari Pacifico.

This very elegant oblongo-elliptical form belongs to the spiral section of the genus. The wings, which have their origin in the subcordate inconspicuously striated valve, are also bent spirally, and, as if to adapt themselves to the curvature of the frustule, they are transversely undulated. This remarkable disposition of the alæ has not hitherto been recognised in any other species, and cannot but be regarded as of specific importance. The apices are broadly rotundate.

Achnanthes, Bory.

Among the pedunculate Diatoms, Bory of St. Vincent established this genus in 1822. It has been defined by Professor W. Smith[2] as follows:—"Frustules geniculate, united into a filament which is stipitate or attached, valves striated, unsymmetrical, the lower with a longitudinal and transverse line, and central and terminal nodules, the upper with a longitudinal line only."

[1] Gregory, *op. cit.*, p. 33, pl. iv. fig. 57.

[2] *Op. cit.*, vol. ii. p. 25.

Achnanthes kerguelenensis, n. sp. (Plate XX. fig. 15.)

Valvis lanceolato-rhombicis; apicibus obtusis rotundatis; striis moniliformibus subradiantibus. Ad insulam Kerguelen.

This frustule has a lanceolate-rhomboidal outline, thus agreeing with *Achnanthes rhomboides* [1] of Ehrenberg, but instead of possessing acute extremities like the latter it has absolutely rounded and obtuse apices.

It was found in a sounding taken near Kerguelen Island.

Achnanthes parallela, n. sp. (Plate XIX. fig. 11.)

Valvis linearibus; apicibus rotundatis; punctulorum lineis subradiantibus. In portu Thaiti.

This frustule was found in sand which proved to be rich in various forms of Diatoms and which was obtained from a great depth at the port of Tahiti. The valves are bounded peripherally by straight parallel lines, the extremities are rounded, and the lines of puncta are subradiating.

No hitherto recorded species agrees with this form, whose specific name has reference to its parallel margins.

TRIBE II.—PSEUDORAPHIDIEÆ.

Gephyria, Arnott.

This genus, as well as that of *Eupleuria*, was established by Professor Walker Arnott, but as it not unfrequently happens that the definitions of new genera when first constituted are very imperfect, and as further examination often demonstrates not their generic but only their specific value, the *Eupleuriæ* and *Gephyriæ* were subsequently united by Professor H. L. Smith, the peculiarities of their structure not being sufficiently well marked to indicate distinct generic characters.

In both types the frustules, which are united together, consist of dissimilar valves, and the transversely disposed lines on these are cut by longitudinal lines. The transverse ribs, moreover, are so arranged that the areas included between them on the two sides of the central band alternate (Plate XV. fig. 10). Both have arcuate valves, but in the case of *Gephyria* [2] the lower valve differs from the upper "in having a smooth circular space at each end," while in *Eupleuria* [3] the inferior valve has "the costæ and striæ disappearing below the extremities of the valve," although these structures reach the extremity in the superior.

[1] This form is identical with *Achnanthes ventricosa*, Kütz., Bac., p. 76, pl. xx. fig. 7, and with *Monogramma ventricosa*, Ehrenb., *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1843.

[2] Pritchard, *op. cit.*, p. 809.

[3] *Quart. Journ. Micr. Sci.*, vol. vi. p. 89.

According to Arnott, the difference between *Gephyria* and *Eupleuria* consists in the fact that in the latter the zonal side is formed of rings of short septa while the margins are beaded, whereas in the former the connecting zone is sublamellate and finely striated on the surface.[1] Since, however, it is true that the shape and structure of the two types are essentially identical, they must be regarded as being generically equivalent, although the *Eupleuriæ* may be considered as a distinct section of the *Gephyriæ*.

Gephyria gigantea, Grev. (Plate XV. fig. 10.)

This figure represents a magnificent Gephyrian valve from the neighbourhood of Kerguelen Island, where numerous interesting Diatoms have been found. It reminds the observer of *Gephyria gigantea*, Grev., which is shown on plate xi. figs. 7 and 8 of the Transactions of the Microscopical Society of London, vol. xiv., new series, 1866. Eugenie O'Meara also describes[2] and figures under the name of *Gephyria dyerana*, in his work on the diatomaceous gatherings made at Kerguelen Island by the Expedition, a form of valve which seems to be identical with that recognised by me from the same spot and very probably from the same collection.

On comparing the three figures above referred to as well as the descriptions given by O'Meara and Greville, no difference is apparent except the circumstance recorded by the former, that the valves are flat in the centre and arched at the extremities. This, however, cannot by itself be regarded as a good foundation on which to establish a new species, so that the form shown on our Plate XV. fig. 10 must be regarded as identical with that described and figured by O'Meara. Moreover, as no distinction is apparent between the latter and the Grevillean type, the designation adopted by the last-named author should be selected on account of its priority.

Gephyria, n. sp. (?) (Plate XXV. fig. 19.)

We have here a representation of the superior valve of a very small Gephyrian frustule, marked by transversely disposed costules which alternate on the two sides. The two halves of the valve are separated by an undulating central line.

It is indeed true that similar characteristics are seen on the valve of *Eupleuria*, and particularly on the superior valve—a circumstance which goes to justify the reunion of the two genera *Gephyria* and *Eupleuria* into one—but since the two valves of the genus are constantly dissimilar, and since, in the present case, the characteristics of the connecting zone are unknown, it may in the meantime be indicated as probably a new species of *Gephyria*, although its true specific or non-specific value can be determined only when its characters are more fully known. This frustule was gathered at the port of Tahiti.

[1] *Quart. Journ. Micr. Sci.*, vol. viii. p. 20.

[2] *Journ. Linn. Soc. Lond.* (Botany), vol. xv. p. 59, pl. i. fig. 10.

Glyphodesmis (Grev.), Cstr.

It is by no means easy to define the two organisms which are represented on Plate XVIII. figs. 12 and 13, in their valval and zonal aspects. Both are navicular, but the one, which is elliptical in form, is very much elongated, while the other has two lateral protuberances. In the centre they possess a very pronounced nodule, as may be well observed when they are viewed from their zonal sides. At each extremity the valve is provided with a small but somewhat elevated cushion, which is extended and flat, and acts as a support between two adjacent frustules of the series. The valve, which is clathrate, is ornamented with quadrate granules disposed in parallel rows.

Naviculoid clathrate valves provided with central nodules are to be found in the Grevillean genus *Glyphodesmis*, but in the latter there are no small terminal cushions such as those present in the frustules represented in our present figures. In Plate x. fig. 7, of the Quarterly Journal of Microscopical Science, vol. ii., new series, 1862, a series of frustules of *Glyphodesmis eximia*, Grev., is represented. These present in their zonal aspects three projecting points which bring about a contact between adjoining frustules, namely, a central one corresponding to the nodule, and two terminal ones. The last are small smooth terminal cushions, and, although not distinctly marked, the presence of terminal protuberances in all *Glyphodesmides* may be regarded as verified, and on this account should be referred to in the definition of the genus. Hence the following definition may be taken instead of that given by Greville:[1]—

Frustulis seriatim conjunctis, valvis navicularibus, nodulo centrali et pulvinulis terminalibus, structura clathrata, granulis transverse quadrato ordine dispositis, linea centrali subconspicua.

Glyphodesmis murrayana, n. sp. (Plate XVIII. fig. 12.)

Maxima, longe elliptica (novies longior quam latior); structura clathrata, granulis subquadratis quadrato ordine dispositis; pulvinulis terminalibus lævibus ellipticis; area centrali transverse elliptica, cui nodulum rotundum inscribitur. Ad insulas Philippinas.

This frustule is remarkable on account of its size, elegance, and clearness of detail. It is ornamented with large subquadrate granules which are arranged in parallel longitudinal and transverse lines and give relief to the smooth oval extremities as well as to the transversely elliptical central area where the large round nodule is conspicuous. When viewed in the zonal aspect the central nodule is seen to be large, elevated, and somewhat flattened at the top. It may also be noted that the nodule does not present an opening or osteole so as to produce a communication between the surrounding medium and the

[1] Greville's definition ran as follows: "Frustules united into a filament; lateral view naviculoid, with a central nodule, median line, and transverse rows of granules; structure clathrate, the granules being developed within square cellules, arranged in parallel series."—*Quart. Journ. Micr. Sci.*, vol. ii., new series, p. 234.

interior of the frustule, as maintained by Kützing, but that, on the contrary, the walls are thick at this place, so that the general opinion that in Diatoms the siliceous nodules are more or less solid protuberances is here confirmed.

The size of this new species, which has been named in honour of Mr John Murray, the Editor of the Challenger Reports, is not less than 200 μ.

Glyphodesmis challengerensis, n. sp. (Plate XVIII. fig. 13.)

Magna, medio constricta; apicibus productis cuneato-rotundatis; pulvinulis terminalibus lævibus ellipticis; nodulo centrali erectiore in area lævi elliptica; punctulis quadrato ordine dispositis; linea axialis in valva latior. Ad mare Philippinarum.

This frustule, which is represented in its valval and zonal aspects, possesses small terminal cushions and a central nodule which are decidedly elevated. The central nodule is not a mere granule like that of the Naviculaceæ, but exists in the form of a large elevated process with a flattened top. This nodule and the terminal cushions are the points by which the adjoining frustules of a series are united to each other.

The valve presents a median constriction and two lateral protuberances. The extremities are prolonged but rounded. The granules, which are punctiform, are disposed in a quadrate manner in parallel rows, and the longitudinal axis is represented by two rows of dots somewhat further apart and more prominent than those in the adjoining rows.

Glyphodesmis margaritacea, n. sp. (Plate XVIII. fig. 10.)

Valvis ellipticis; granulis distinctioribus quadrato ordine dispositis et transverse per plicas distinctis, ad apices et ad centrum areæ læves, in area centrali nodulum subobscurum. Ad Zebu, in mari Philippinarum.

This frustule, which is only represented in its valval aspect, possesses a very elegant elliptical form. The valve is ornamented with beautiful round granules disposed in a quadrate manner. It is crossed by transverse folds, and in its centre as well as at its extremities there are smooth areas which, however, are less clearly defined than in the two preceding species. In the central area the nodule is not prominent, and greatly resembles that of *Glyphodesmis eximia*, Grev., but the nature of the valvular sculpturing is quite distinct.

The frustule figured is of large dimensions.

Glyphodesmis (?) an *Dimeregramma* (?) sp. (?) (Plate XIX. fig. 10.)

This figure represents a series of small frustules seen in the zonal aspect, but, since the genera *Glyphodesmis* and *Dimeregramma* can be distinguished only when viewed in their valval aspects—the essential distinction being found in the presence of a central nodule

on the valve of *Glyphodesmis*—its generic determination must remain uncertain. This being so, the specific characters, which can be better divined than decided with certainty, may at present be left out of consideration.

Plagiogramma, Grev.

Greville[1] instituted this genus in 1859, and defined it as follows:—Frustules quadrangular, direct, two or more united into a filament; valves linear or elliptical; striæ moniliform; vittæ two or more, pervious, parallel with the striæ.

Plagiogramma thaitiense, n. sp. (Plate XIX. fig. 4.)

Frustulis rectangularibus subinflatis; vittis duabus centralibus perviis; striis transversis tenuioribus ad extremum usque. Ad portum Thaiti.

This Diatom was obtained at the port of Tahiti. It recalls the *Plagiogramma jamaicense*[2] of Greville in the fact that the striæ, which appear on the margins of the connecting zone, are continued to the angles. In the type now under examination, however, while the striæ extend absolutely as far as the extremities, they are much more delicate than in the Grevillean species, while the margins of the frustule, when viewed in the zonal aspect, are somewhat protuberant in the centre, whereas in *Plagiogramma jamaicense* they are straight if not even slightly concave.

Although each of these points of distinction when taken by itself may be of small value, when they are considered collectively they must be regarded as sufficient for the establishing of a new species.

Plagiogramma margaritaceum, n. sp. (Plate XIX. fig. 13.)

Valvis late ellipticis, convexiusculis; granulis distinctioribus quadrato ordine dispositis; granuli inter medias costas vacant, ad apices evanescunt. In portu Thaiti.

This frustule, which is also from the port of Tahiti, possesses an elliptical outline, and, as indicated by the curves of the transverse lines which separate the rows of granules, is markedly convex. The striation is continued to the extreme apices but the striæ are not moniliform—a fact which, however, cannot be regarded as of essential importance. On this ground *Plagiogramma tessellatum*, to which Gregory affixed a note of interrogation, must also be admitted to be a true *Plagiogramma*.

[1] *Micr. Journ.*, vol. vii. p. 208. Greville here divided the genus into three sections, according to the character of the vittæ, viz., Sect. I. Vittæ two, centrical; Sect. II. Vittæ two, centrical, and one at each end of the valve; Sect. III. Number of vittæ between the two centrical ones and the ends of the valve indefinite.

[2] *Micr. Journ.*, vol. vii. p. 208, pl. x. fig. 3.

Dimeregramma, Ralfs.

Among filamentous Diatoms the genus *Dimeregramma* is closely allied to that of *Denticula*, the only distinction consisting in the valves of the former always possessing a smooth line which marks the longitudinal axis, while those of the latter do not exhibit such a structure.[1] The majority of the known species which are now ascribed to *Dimeregramma*, and which were discovered by Gregory before this genus was instituted, were accordingly classed by him as belonging to the group *Denticula*, the forms recorded by that observer, however, being marine, while the others were all freshwater species.

Dimeregramma nanum, Greg., var. *thaitiensis*, nov. (Plate XIX. fig. 5.)

Among the *Dimeregrammata* collected by H.M.S. Challenger, the only noteworthy specimens are those here figured. These greatly resemble the *Dimeregramma nanum* of Gregory,[2] differing from it only in the form of the extremities, which in the present case are more dilated and round. Such a distinction, however, cannot be viewed as possessing more than a varietal importance.

Terebraria, Greville.

This genus was established by Greville in 1864, when he made us acquainted with the *Terebraria barbadensis*, from the famous Barbados deposit in Cambridge. The definition of the genus as given by him[3] ran as follows:—"Frustules in front view quadrangular, binately conjoined, with transverse rows of conspicuous pseudopores and a longitudinal serrated structure. Valve elliptical, with transverse rows of similar pseudopores."

To the species made known by Greville, O'Meara added his *Terebraria kerguelensis*, which was obtained from a gathering made by the Expedition in the vicinity of Kerguelen, and which has been figured in the Journal of the Linnean Society (Botany) vol. xv. pl. 1, fig. 4. I am, however, in doubt with regard to the correct determination of this frustule. By referring to the description of the genus, or to the figure given by Greville, the indented line of suture is found to be so evident as to constitute one of the principal characteristics, whereas in the figure given by O'Meara no such lines of suture are to be perceived; but, on the contrary, on the *zonal* side the granules alternate, so that in the line of division between the two adjacent valves there is an appearance resembling that presented by an indented suturation. It would seem, therefore, from the fact that O'Meara, in his definition of *Terebraria kerguelensis*, omitted to notice this circumstance, that he took the central line of the zone in *Terebraria barbadensis*, Grev., not for what it

[1] Pritchard, *op. cit.*, p. 790.

[2] = *Denticula nana*, Greg., Diatoms of the Clyde, p. 23, pl. ii. fig. 34.

[3] *Trans. Micros. Soc. Lond.*, new series, vol. xii. p. 8., figs. 12 and 13.

really is, but for a profile of alternating granules belonging to two different valves. Moreover, judging from the figure of the zonal side of *Terebraria kerguelensis*, O'Me., we cannot recognise in this type the condition of a frustule "binately conjoined." Nor can it be admitted that the so-called *Terebraria kerguelensis*, O'Me., should be classed with *Terebraria barbadensis*, Grev., and it is not easy to decide to what other genus the form in question should be ascribed, so that, though with reservation, the name given by O'Meara may for the present be retained.

Terebraria (?) sp. (?) (Plate XXV. fig. 2.)

This figure represents an organism obtained to the south of Heard Island, which shows seven lines having the appearance of indented lines of suture similar to those which have been observed on the zonal side of *Terebraria kerguelensis*, O'Me. It may be observed that the undulating lines are disposed around corresponding straight lines, and that at each of these regions a solution of continuity takes place as a result of the fitting together of the two valves which seem to alternate with one another as in O'Meara's species. In this figure, too, it is to be noted that the granules or costules which are seen in profile differ greatly in number in the different valves. Yet it cannot be doubted, as some have done, that the striation or the granulation of a frustule, presents *within certain limits* good characteristic features for diagnostic purposes, although the necessity for exercising caution in generalising on such appearances is at once obvious. This has already been referred to by me in the Transactions of the Pontifical Academy,[1] where the fact that other Diatoms, such as *Eunotia formica*,[2] Ehrenb., have the striæ irregularly distributed not only on different frustules, but also on the same valve, has been recorded. Apart, however, from the circumstance of the magnitude of the striæ based upon the comparison of the undulated lines of division with those that are found in *Terebraria kerguelensis*, O'Me., this new type may for the present be named *Terebraria*, although no specific designation can be given, as the characteristics of the valves have not yet been adequately determined.

Plate XXV. fig. 1 also represents a series of frustules which, although probably not members of the genus *Terebraria*, but of the genus *Fragilaria*, yet exhibit, when seen in the zonal aspect, some relation to the *Terebraria kerguelensis* of O'Meara, although they cannot be regarded as identical with that species. The frustules have evidently been obtained at different stages of development. The uppermost in the figure has recently undergone fissiparous division, but the resulting cellules have not yet become detached, although the margins of the adjoining valves are now clearly indicated by the two transverse central rows of granules. This phase would seem to be a repetition of the condition re-

[1] *Atti Accad. Pontif. d. nuov. Lincei*, vol. xxxi. sect. 6.

[2] Ehrenberg, Mikrogeol., pl. iii. iv. fig. 18.

cognisable in the frustule figured by O'Meara, but the alternation of the granules of the two new valves which cause the latter to possess an apparent indented line of suturation is not here visible.

The next three frustules of the series have gone on developing after fission, and now present two symmetrically convex valves, which are again ready to divide. The fifth, which is probably younger than the second, third, or fourth, as its cingulum is less developed, is obviously advancing towards the same mature state. The sixth, on the other hand, is evidently imperfect, having originated from that immediately preceding it. Its abortive condition presents a phenomenon similar to what not unfrequently occurs in the almond and other fruits or seeds, where one part may develop at the expense of the others. The remaining frustules, again, show somewhat advanced phases, recalling the appearances presented by the second, third, and fourth.

From the developmental stages here seen, great interest attaches to this figure, but it is to be carefully observed that the granules, instead of alternating, are arranged in continuous and parallel series along the lines of division.

At present even the generic determination of these Diatoms must remain uncertain until the form of the valve from its valval aspect has been fully studied.

Rhaphoneis, Ehrenb.

Authors are not agreed as to the definition of this genus. Pritchard,[1] among others, limits the name to those navicular forms in which the centre is unprovided with noduli and transversely directed lines, whilst Rabenhorst[2] admits those forms that possess costules. Although it is desirable to limit the number of species in the various genera as far as possible in order to facilitate study, it is better in the present case to follow the opinion of Rabenhorst, especially as the species are not very numerous. The following is the definition of the genus as given by that author :—"Frustula libera vel stipitata, quadrangula simplicia navicularia, non conjuncta, fronte late lanceolata vel ovata, nodulis nullis, striis vel costis transversis, ubi adsunt, vitta vel area longitudinali interruptis."

Rhaphoneis mammalis, n. sp. (Plate XXVI. fig. 3.)

Elliptico lanceolata; apicibus productis mammiformibus; costis raris radiantibus; vitta sublineari medio interrupta. Ad portum Thaiti.

This beautiful frustule was found in an interesting collection from the port of Tahiti. Its form is elliptico-lanceolate, and its extremities are mammiform, while its transverse and longitudinal axes are in the proportion of two to three. Its widely disposed costules are radiating and interrupted in the middle by a narrow lineal smooth area.

This species has been named from the appearance presented by its extremities.

[1] *Op. cit.*, p. 791. [2] Flora Europæa Algarum Aquæ dulcis et submarinæ, sect. 1, p. 125.

Rhaphoneis elliptica, n. sp. (Plate XXVI. fig. 13.)

Parva, elliptica, duplo longior quam latior; costis crebriusculis radiantibus, area lineari lanceolata medio interruptis. Ad mare Japonicum.

This small elliptical Diatom is twice as long as broad. Its costules, which radiate like those of *Rhaphoneis mammalis*, n. sp., are more closely arranged, and more prominent than in the latter frustule.

The smallness of its size, and the absence of granulated striæ, distinguish it from the *Rhaphoneis fasciolata* of Ehrenberg,[1] but it bears some resemblance to the lower valve of a *Cocconeis*. Since, however, no upper valve belonging to this genus was observed in the rich collection, and since the smooth central space characteristic of the genus *Rhaphoneis* is present, it has from its shape been named *Rhaphoneis elliptica*. It was gathered in the Sea of Japan.

Rhaphoneis japonica, n. sp. (Plate XIX. fig. 12.)

Mediocris, elliptica; apicibus cuneato rotundatis; distinctiorum granulorum lineis subradiantibus; granulis circum regulariter stipatis, medio irregulariter rarioribus. In mari Japonico.

The determination of this species has been a work of no small difficulty. In it no trace of a smooth area or of a median longitudinal line is to be found, so that, although apparently not a *Rhaphoneis*, no other genus exists to which it could be more readily ascribed. On consulting the various writers on Diatoms, and comparing their figures with the present type, an oblong, elliptical form—different, indeed, from the form now in question, but evidently belonging to the same genus,—which resembles the *Rhaphoneis australis* of H. L. Smith, is represented at fig. 54 given in a paper on the "Diatoms collected during the Expedition of the Vega," by P. T. Cleve, under the name of *Trachisphenia australis*.

In order to understand how a form that presents no trace of central division can be called a *Rhaphoneis*, reference may be made to the Synopsis of the families and genera of Diatoms by H. L. Smith, as given at the end of Dr Van Heurck's work on the Microscope[2] (third edition), where, in the definition of the genus, after having said, "ayant une ligne mediane ou un espace blanc," he parenthetically adds, "souvent obscur ou manquant," so that amongst the characteristics of a genus the essential should always be distinguished from the less essential features.

Since, however, this frustule from the Sea of Japan cannot be confounded with *Rhaphoneis australis*, H. L. Sm., as it differs both in form and in the character of its granulation, it must be regarded as a new species, and has been named from the locality in which it was found.

[1] Mikrogeol., T. XXXV. A. 22, fig. 16.

[2] Le Microscope, sa Construction, son Mainement, et son Application à l'anatomie Végetale et aux Diatomées (troisieme Edition), Bruxelles, 1878.

Asterionella, Hassall.

The genus *Asterionella*, instituted by Hassall in 1855, is characterised by the following features: (1) Its frustules are grouped in a stellate manner, and (2) when viewed in profile they are constantly inflated at the base, and sometimes also at their superior extremities.

Up to the present time all the species included in this genus have been freshwater forms, with the exception of the *Asterionella bleakeleyii* of W. Smith and the *Asterionella frauenfeldii* of Grunow, the latter of which was afterwards ascribed to the genus *Thalassiothrix*. Among the collections procured by the Challenger, however, two different types, which were gathered on the surface of the Antarctic Ocean near the ice-barrier of the South Pole, must be ascribed to the *Asterionellæ*, but it is to be borne in mind that, as numerous frustules of *Eunotia arcus*, W. Sm.,[1] were found in the same collection, it is unquestionable that in many cases terrestrial Diatoms which vegetate on the glaciers of the Antarctic, and which represent the last traces of the icebergs that have been melted by coming into contact with warmer water, float upon the surface of the waters in these localities. Moreover, since it has been clearly proved that the other species of the genus *Eunotia* do not vegetate except at an elevation of several hundred feet above the level of the sea, it is manifest that it is impossible here to decide whether the *Asterionellæ*, which have now to be recorded, should be regarded as terrestrial forms, or whether they must be viewed as being strictly marine.

Although these new forms cannot be identified with *Asterionella bleakeleyii* of W. Smith, which was till recently the only marine species that had been observed, it may here be remarked that I have observed other marine *Asterionellæ* at the island of Lesina in Dalmatia—a region which is exceedingly favourable for research in this department of marine biology. In this locality, by means of small nets, there was found on the surface of the sea, and floating among many other organic forms, an *Asterionella* which could be readily distinguished by the linear form of the frustules; these were at the same time provided with a swelling at the inferior extremity, and were radiately disposed so as to present a stellate appearance. This form, too, was remarkable from the fact that the series did not form a solitary star with only a few radii, but presented, on the contrary, a long chain of very numerous frustules, which were disposed in such a manner as to form several spiral turns, so that the name *Asterionella spiralis*, which has been applied to the species, is exceedingly characteristic.

Asterionella glacialis, n. sp. (Plate XIV. fig. 1.)

Frustula a basi inflata exiliter linearia; valvis inferius rotundato-inflatis, et binis lineolis notatis. In mari Antarctico.

[1] Synopsis of the British Diatomaceæ, vol. i. p. 15, pl. ii. fig. 15. This Diatom is equivalent to *Navicula arcus*, Ehrenb., Inf., pl. xxi. fig. 10, *Cymbella* (?) *arcus*, Hass., Alg., C. 6, and to *Ceratoneis arcus*, Kg., Bac., pl. vi. fig. 10.

The frustules of this type, which was collected in the Antarctic Ocean, show a characteristic peculiarity at their inferior extremities, and one which is not found in any frustule of *Asterionella bleakeleyii*, W. Sm., namely, the presence, on the zonal side, of two small symmetrical lines, which run in the direction of their long axes. These probably represent the incapsuling of the two valves of the frustule, and if so, ought to have been visible in *Asterionella bleakeleyii*, though contracted as a result of incineration.

Nor can *Asterionella glacialis* be confounded with the freshwater *Asterionella formosa* of Hassall,[1] as the latter has its superior extremity somewhat swollen, although to a less extent than its inferior extremity, while the former has a swelling only at the inferior extremity of the valve, and on the zonal side of the frustule, so that it must be regarded as a new species.

Asterionella gracillima (Hantzsch.), Heib. (Plate XXV. fig. 6.)

We have here represented a form which cannot be confounded with the *Asterionella bleakeleyii* of W. Smith, as, instead of being linear in the parts succeeding the dilated base, it is sensibly swollen at its superior extremity. The specimen, however, which unfortunately has suffered somewhat from the bleaching process, agrees better with *Asterionella gracillima*[2] (Hantzsch.), Heib., in its morphological characteristics; but, instead of being found in fresh water, like the latter, it occurred on the surface of the sea. As it may have been borne to that locality by glaciers and icebergs, it may, for the present, be viewed as identical with that species.

Synedra, Ehrenb.

This genus is chiefly characterised by having its small frustules joined by means of a cushion, or sometimes of a more or less developed peduncle to seaweeds or other objects. The attachment thus effected is of a feeble kind, so that it is a very common occurrence to find living specimens in a free state, and in the examination of geological diatomaceous deposits, or of frustules that have been treated with acids, it is impossible to determine whether any given form existed in the free or adherent condition. But apart from its attached or non-attached habit, the genus cannot, on account of its structural peculiarities, be confounded with any other. Its closest affinity is to be found in the *Bacillariæ*, from which, however, it is readily distinguishable by the presence in the latter of a characteristic punctated keel. Nor can it be confounded with the *Asterionellæ*, Hass., or with members of the genus *Thalassiothrix* (Grun.), Cstr., inasmuch as it does not possess large broad or dilated extremities, but is provided either with a small cushion, which unites the frustules in a star-like manner, or with small triangular pads placed laterally at the two extremities,

[1] *Micr. Journ.*, vol. viii. pl. vii. fig. 8; Heiberg, Conspec., pl. vi. fig. 20.

[2] Heiberg, Conspec., p. 68, pl. vi. fig. 19; = *Diatoma gracillimum*, Hantzsch. in Rabenh. Alg., No. 1104, c. icone, Krypt. Flor. von Sachsen, p. 32.

and serving as means of union into zig-zag chains. In acid preparations the differentiation of the *Synedræ* from species belonging to the genus *Thalassiothrix* is a matter of greater difficulty, but in general this may be done by remembering that the latter are distinguished by lateral rows of much raised thorn-like points so that each of the outer extremities terminates in two projecting apiculi.

Synedra capitulata, n. sp. (Plate XXV. fig. 13.)

Lineari-lanceolata, apicibus dilatatis, rotundatis, valvis medio lævibus, ad marginem ordine brevissimarum linearum circumdatis. In mare Philippinarum.

This very elegant Diatom, which was obtained in a sounding made in the neighbourhood of the Philippine Islands, possesses a linear-lanceolate outline. Its extremities are dilated and rounded, and the valve is surrounded by thick short lines, whilst the remainder of the surface is smooth.

The specific name has reference to the capitate appearance of the extremities.

Synedra philippinarum, n. sp. (Plate XXV. fig. 15.)

Gracillima ; valvis angustissime lanceolatis ; apicibus linearibus obtusis ; striis transversis continuis. In mari Philippinarum.

This very slender frustule, also from the sea in the vicinity of the Philippine Islands, presents a slightly arched appearance. The extremities are linear and obtuse, and the striæ are transverse and continuous. The fact that this species was represented by many specimens is opposed to the idea that it was originally a freshwater form which had been floated into the ocean, although it may be noted that most slender and crooked forms of the genus are from fresh water.

Synedra fimbriata, n. sp. (Plate XXV. fig. 14.)

Rhomboideo-lanceolata ; apicibus rotundatis ; striis transversis, ad marginem evidentioribus et vittam linearem constituentibus. Ad oras Philippinarum.

The valve in this type is sub-rhomboideo-lanceolate. The centre is convex, the convexity lessening towards the rounded extremities. The surface of the valve is ornamented with continuous transverse striæ, which become salient near the margins, and thus form a more prominent outline—a circumstance which has suggested its specific name.

Synedra lanceolata, n. sp. (Plate XXV. fig. 20.)

Parva, lanceolata ; apicibus cuneato-acutis ; striis perspicuis transversis, linea lævi medio interruptis ; striæ 1400 in millimetro numerantur. Ad insulam Heard.

This frustule was collected near Heard Island in the Antarctic Ocean. It may be

distinguished from a *Navicula* by the absence of the characteristic nodule of the latter, but its striæ are interrupted by a simple longitudinal line.[1] This feature, taken in conjunction with the cuneato-acute appearance of its extremities, constitutes a very distinct specific type.

Synedra lanceolata, n. sp., var. *thaitiensis*, nov. (Plate XXV. fig. 18.)

This frustule, which is similar to the preceding, was found in a gathering from the port of Tahiti. It may, however, be distinguished from *Synedra lanceolata* by its somewhat finer striæ, which are interrupted by a fine line, but it cannot be regarded as more than a variety of that type.

Synedra atlantica, n. sp. (Plate XXV. fig. 16.)

Lanceolata, elongata ; apicibus rotundatis ; striis evidentioribus transversis continuis, binis lineis submarginalibus unilateraliter sectis. In Oceano Atlantico meridionali.

This Diatom was obtained from a sounding made in the middle of the South Atlantic. Its valves are lanceolate, and are provided with rounded apices. The striation is well marked transversely directed and continuous, but is cut on one side by two submarginal lines, the signification of which is not manifest, although they must be regarded as characteristic of the species.

Thalassiothrix (Grun.), Cstr.

Among the surface collections made in the Bay of Yedo and in the waters around Hong-Kong there has been found in great abundance a Diatom of a bacillar form, which is either long and straight, or short and slightly curved in appearance, and which generally occurs in small groups, the frustules being arranged either in a radiating manner or forming a zig-zag series. The individual Diatoms are bordered by lines of very elevated granules, so that the outer extremities are crowned by two apiculi. Similar frustules have also been observed by me in surface collections made in the Adriatic off the coast of Dalmatia, and on the Italian coast at Rimini and Fano. In specimens procured at the last-named localities, and which had not been subjected to any incinerating process, the frustules were found in groups of not more than eight, and were simple or double and united in a radiating manner, the inferior extremities being sunk in a small transparent cushion of the form of an armilla, which is destroyed by the action of heat. Not unfrequently a few similar frustules were seen in zig-zag position, and it was of interest to observe that when a normal radiating group of simple frustules was undergoing fission, and so becoming double, the cushion broke by the separation of two contiguous frustules.

[1] The *double* central line has been figured by mistake.

These remained united, however, by a small triangular cushion at the superior extremity of the two recently formed valves.

This same Diatom was also found among the collections made at Tilanshang, one of the Nicobar Islands, by the Austrian scientific frigate "Novara," and was named by A. Grunow *Asterionella frauenfeldii*;[1] but, with this exception, no other naturalist has recorded its occurrence, although it is found in almost all seas.

Although at first sight this curious Diatom recalls the genus *Asterionella*, it is to be remarked that in the latter the inferior extremities of the frustules are dilated and are in contact with one another instead of adhering by means of small cushions.

In the Synopsis des Diatomées de Belgique, by van Heurck and Grunow, which has recently appeared, and in the section of Pseudoraphidieæ (plate xxxvii.) the forms which Grunow named *Asterionella frauenfeldii* are referred to the new genus *Thalassiothrix*, to which there is also ascribed the very singular *Synedra thalassiothrix* of Cleve. But, after a careful comparison of these two forms, they cannot be regarded as congeners, the one—*Asterionella frauenfeldii*—having its frustules united by small membranous cushions, while the other—*Synedra thalassiothrix*—is solitary or disposed in parallel bands.

With regard to the genus *Thalassiothrix*, Grunow says that it embraces some species resembling Asterionella, but having on the margins spines or elevated points between which one sees a short marginal striation. The structure here described is indeed precisely that of the *Synedra thalassiothrix* of Cleve; but it cannot in any way be compared to that of *Asterionella frauenfeldii*, the bacillar Diatom in which there is only to be discovered a line of very salient marginal granules, which render the two small apices indistinct. Hence it would be better, at least for the present, to exclude Cleve's *Synedra thalassiothrix* from the genus *Thalassiothrix* altogether.

But the *Thalassiothrix* (*Asterionella*) *frauenfeldii* of Grunow may, on the other hand, be retained in that genus, although the generic definition must be somewhat modified. It may be amended as follows:—Frustulis linearibus radiatim per pulvinulum gelineum armilliforme unitis, bino erectiorum punctulorum ordine instructis; post frustulorum deduplicatione armilla disrumpitur, et frustula in seriem alternam per isthmum triangularem cohalescunt.

Thalassiothrix frauenfeldii (Grun.), Cstr. (Plate XIV. figs. 7 and 8.)

Frustulis radiatim conjunctis, hinc in catenas alternas dispositis; a latere zonali anguste linearis, valvis arctissime linearibus, utroque margine serie unica punctulorum (spinularum?) evidentium ornatis. Ad insulas Nicobar, ad Java, in mari Sinensi et Japonico, in Adriatico, in Tyreno et alibi.

[1] *Verhandl. d. k. k. zool.-bot. Gesellsch. in Wien*, 1863, p. 140, pl. xiv.—Diatomaceen der Novara-Expedition —fig. 18.

In fig. 8 the frustules are simple and singularly slender, and the borders are provided with fine but very salient points—spines or thorns—which at the superior extremity assume the appearance of two apiculi. The frustules are never in groups of more than eight, and the angles included between any adjoining pair are approximately equal, with the exception of that which corresponds to the opening of the armilla, which is always somewhat larger.

This also applies to the frustules shown in fig. 7, which differ from the last only in being double, an appearance which has been caused by the temnogenetic changes which have taken place. Sometimes promiscuous groups of double or simple frustules are to be met with, but much more frequently, after division has occurred, the armilla, in which the inferior extremities of the frustules are planted, breaks up by separation of the double frustules, a result which is probably brought about by the development and swelling of a triangular isthmus, which unites the superior extremities. In the course of this curious change in the position of the locus of union the frustules are frequently found to be simply united in short zig-zag series.

Thalassiothrix curvata, n. sp. (Plate XXIV. fig. 6.)

Frustulis linearibus, subcurvatis, crasiusculis, radiatim vel alterne pulvinulo conjunctis; punctulis frustulorum marginalibus duplo quam in *Thalassiothrice frauenfeldii* rarioribus. In mari Japonico.

In this figure no traces of the small connecting cushions are to be found, as these have been removed during the process of incineration. The frustules are bacillar, and flanked on each side by a line of small points resembling those which are found in the above described Grunowian species, but they are slightly curved, much shorter and wider, and the punctations are only half as abundant as in *Thalassiothrix frauenfeldii*.

From such considerations the specific value of this Diatom cannot be doubted, especially as it occurs in great abundance in some collections.

Fragilaria (Lyngb.), Agardh.

It has already been indicated that the enormous glaciers which cover the mountains of polar lands, and which ultimately reach the ocean and form icebergs, are the means of transporting freshwater Diatoms into the sea, where these organisms float freely when the ice has been melted. Frustules of *Asterionella formosa*, Hass., *Ceratoneis arcus*, Kg., and various species of the genus *Eunotia*, which is not only peculiar to fresh water, but which only vegetates at an elevation of several hundred feet above the level of the sea, have been thus transported,[1] and the same phenomenon has taken place in the case of the genus *Fragilaria*, of which some new species must now be recorded.

[1] Confer., p. 50.

Fragilaria linearis, n. sp. (Plate XIX. fig. 9.)

E maximis; valvis linearibus, transverse striatis, apicibus rotundatis. In mari Antarctico.

This Diatom was collected in the Antarctic Ocean. The form of the valve is not "linear-lanceolate or fusiform," but is absolutely linear, and provided with rounded extremities, so that in this respect it differs from that of any previously recorded species of the genus. Hence Pritchard's definition,[1] as given in his History of Infusoria (p. 776), must be extended, there being no doubt as to the fact that this frustule belongs to the present genus. The generic description may be amended as follows :—"Frustules linear, united into a filament, lateral valves smooth or faintly striated, linear, linear-lanceolate or fusiform."

Fragilaria antarctica, n. sp. (Plate XXV. fig. 12.)

Frustulis seriatim dispositis; valvis plus minus subcurvatis, transverse raro plicatis; inter plicas duplex punctulorum ordo; punctula invicem alternantur. In mari Antarctico passim.

The two valves shown in the present figure are of very different sizes, yet the identity of their structure indicates that they belong to the same genus, although in the larger specimen the want of symmetry along the longitudinal axis is more pronounced than in the other. This want of symmetry is not found in other forms of *Fragilaria*, except in the case of *Fragilaria* (?) *pacifica*,[2] Grun., which is figured in the Synopsis des Diatomées de Belgique, Plate xliv. figs. 20–22, and of *Fragilaria* (?) *schwarzii*, Grun., represented at fig. 24 of the same plate. With these two examples before us, however, the present frustules may be classed as *Fragilariæ*, especially as the valves are striated by uninterrupted rows of points—a character which is generally found in the *Fragilariæ*. Strictly speaking, however, this type should not be placed among the Pseudoraphidieæ, but among the Cryptoraphiiedæ.

The structure of the valves is very characteristic. The surface is traversed transversely by thinly-set but deep folds, so that the intervals resemble large granules when viewed from the zonal side. Between the folds or plicæ there are two lines of sparsely disposed punctiform granules, which alternate with one another. The Diatom is very common, and is quite characteristic of all the collections from the Antarctic, being found sometimes isolated and sometimes in series. When in series the frustules are not linear, but somewhat inflated, owing to the convexity of their outline.

[1] This definition is as follows: "Frustules linear, united into a filament; lateral valves smooth or faintly striated, linear-lanceolate or fusiform."

[2] The localities given for *Fragilaria* (?) *pacifica*, Grun., are "Cap. de Bonne-Esperance et Iles Samoa," and for *Fragilaria* (?) *schwarzii*, Grun., "Iles Seychelles."

Plate XXV. fig. 11, represents two Fragilarian valves, the first of which belongs to the new *Fragilaria linearis*[1] above described, but the determination of the second, which is of lanceolate form and differs markedly in its striation, is uncertain, as nothing except the valve is known.

The frustules seen at fig. 17 of the same plate must also remain undetermined. They possess a very elegant oblongo-lanceolate form, are provided with acute apices, and are transversely marked with alternating light and dark zones. These rare specimens were found in mud obtained from a sounding in the neighbourhood of Japan, and their characteristic features are not yet fully known.

Diatoma, De Candolle.

Diatoma rhombicum, O'Me. (Plate XXV. fig. 22.)

We have here represented a small elliptical valve, which was found in a gathering made to the south of Heard Island. In a paper on the Diatomaceous Gatherings made at Kerguelen Island, by O'Meara, and published in the Linnean Society's Journal (Botany), vol. xv., this frustule is seen on Plate i. fig. 2. Of the accuracy of the generic determination there can be no doubt, especially as O'Meara has also figured a series of many frustules disposed in a zig-zag manner, nor can there be any question as to the identity of the Diatom now represented with O'Meara's specimens. The definition given of the typical Diatom is as follows: "Frustules small, about ·0006 in length. On front view quadrangular, the costæ appearing as a narrow band of puncta. On side view rhombic; costæ very fine, pervious."

Grammatophora, Ehrenb.

Grammatophora stricta, Ehrenb., var. nov. (Plate XXIX. fig. 12.)

We have here represented the only frustule belonging to this genus which calls for particular attention, and which was collected in the Sea of Japan. It is closely related to the *Grammatophora stricta* of Ehrenberg,[2] as figured by Kützing in his work entitled Die kieselschaligen Bacillarien oder Diatomeen, Plate xxix. fig. 76; but the latter is somewhat larger, the septa are not so straight, and at the polar extremities these are not flanked by a small appendage. Such points of difference, however, cannot be regarded as of more than varietal importance.

Cyclophora, n. gen.

In February 1878 I read before the Pontifical Academy[3] a communication, in which I made known a new *Tabellaria*, which I had met with some years before adhering to

[1] Compare Plate XIX. fig. 9.

[2] Ehrenb., Verb. T. I. i. fig. 22, and T. III. vii. fig. 31; Rabenhorst, Flora Europæa Algarum, p. 305.

[3] *Atti. Accad. Pontif. d. nuov. Lincei*, 1878.

seaweeds on a rock called St Clement's near the port of Ancona, and which was also abundantly represented in a collection of Diatoms from the aquarium of the Zoological Station at Naples. This organism might easily be confounded at first sight with *Diatoma hyalinum*,[1] Kg.; but a careful examination of the former reveals the fact that the markings are more frequent on the zonal side, and that in the middle of one of the longitudinal lines an appearance resembling the letter C is presented. The frustules, as in all *Tabellariæ*, are united in a zig-zag series, and it is exceptional to see one frustule by the side of another or lying isolated. They are connected with each other by means of small membranous cushions generally placed at the angles. In the longitudinal series the position of these points of union alternates from right to left, but in the lateral series they are on the same side in all. Hence in this genus, as in *Cocconeis* and *Achnanthes*, the valves are dissimilar to one another, the loculus of one being round.

The genus *Cyclophora* may accordingly be defined as follows:—Frustula tabulata, rectangula, in fascias conjuncta, rarius soluta; isthmo gelineo alterne concatenata; a fronte linearia vel parum inflata; valvis inæqualibus, quarum una loculo centrali instructa.

This genus, of which *Cyclophora tenuis*, Cstr., is the typical species, has been accepted by all micrographers. Prof. H. L. Smith has recognised it in a recent collection made in America, and Grunow, in the Synopsis des Diatomées de Belgique, has given on Plate xxxvi. figures of *Cyclophora tenuis*, Cstr., and of a variety—*Cyclophora tenuis*, Cstr., var. *tropica*—which was collected in the vicinity of Honduras, the Barbados, and the Isle of France.

In a note annexed to his table Grunow[2] remarks that in addition to the longitudinal lines, the valves show very fine transverse lines and two terminal nodules; but it is to be noted that the longitudinal lines, at least, are only on the zonal side. If these two characteristics really exist the definition should be modified, and the existence of the two terminal nodules would render the systematic position of the genus very problematical. On the valves I have hitherto been able to distinguish nothing except the loculus and a slight central line on one of the valves.

Cyclophora tenuis, Cstr., var. nov. (Plate XXV. fig. 3.)

We have here delineated two frustules from the Philippine Islands, which were united together and evidently belong to the same genus. These frustules resemble in their profile the figure of *Cyclophora tenuis* given by Grunow, but do not agree

[1] Kütz., Bac., p. 47, pl. xvii. fig. 20; Smith, Synopsis of the British Diatomaceæ, vol. ii. p. 41, pl. xli. fig. 312; Pritchard, *op. cit.*, p. 778, pl. iv. fig. 16.

[2] The original note is as follows: "Les valves ont des lignes médianes et des nodules terminaux bien marqués. Ces derniers sont un peu éloignés des extrémités qui sont obtuses. Les striæ transversales dépassent le nombre de 30 en 0·01 mill. Les lignes longitudinales sont délicates et un peu ondulées."

with the typical and most common form already figured in its zonal and valval aspects by me.[1] It is rare to find a zonal presentation of such a frustule, but the appearance presented by the extremities discovers to the observer that the valve is not linear but inflated, and so probably represents a distinct species. In the absence, however, of more conclusive arguments I have chosen to regard it as possessing nothing more than varietal characteristics.

Surirella, Turp., Ehrenb., W. Sm.

Although the recognition of this genus is an easy matter, the determination of its species is a work of great difficulty. The structural details of the Diatoms are constantly found in a more or less developed condition, being sometimes scarcely even outlined, so that it is common to find frustules having the same structural peculiarities, though possessing widely different external contours.

The genus was first established by Turpin[2] in 1827, and afterwards adopted with modifications by Ehrenberg. Its conception was finally limited by W. Smith, who defined it thus :—"Frustules free, ovate, or elliptical, valves with a longitudinal central line, and margins produced into alæ ; canaliculi distinct, usually parallel." But there are two considerations which are obstacles in the way of our accepting this definition. Firstly, types with a linear form, but which have all the other principal characteristics, such as *Surirella linearis*,[3] W. Sm., and still more *Surirella arctissima*, A. S., the valve of which is figured in the Atlas of Schmidt, Plate lvi. figs. 13 and 14, are excluded. The linear form may, however, be looked upon as derived from the oval or elliptical by a process of elongation, while the panduriform outline results from the contraction of an oval form. Secondly, the definition cannot be adapted to some specific types, which, although they exhibit all the other characters of *Surirellæ*, are not provided with a central line. Hence not a few species at present classed as *Surirellæ* should be eliminated, as, for example, the *Surirella fastuosa*, Ehrenb., var. *abludens*,[4] Grun., the *Surirella intercedens*,[5] Grun., and others. This difficulty may readily be overcome by excluding from the definition the clause which demands the presence of a central line.

Surirella dives, n. sp. (Plate X. fig. 4.)

Forma elliptica, canaliculis radiantibus, margine denticulatis, a media superficie nascentibus, area centrali arcte lanceolata, et lineolarum corona cincta, et medio paucis lineolis transverse signata ; margine striato. Ad Zebu, in mari Philippinarum.

This beautiful elliptical frustule is noteworthy on account of its well-developed

[1] *Atti. Accad. Pontif. d. nuov. Lincei*, vol. xxxv. sec. 6, May 21, 1882.
[2] *Mem. du Mus. d'hist. nat.*, vol xvi.
[3] Synopsis of the British Diatomaceæ, vol. i. p. 31, pl. viii. fig. 58.
[4] Schmidt's Atlas, pl. xix. fig. 1.
[5] Schmidt's Atlas, pl. xix. figs. 5 and 6.

canaliculi, which originate from the centre of the valve. In the middle there is a narrow lanceolate area circumscribed by a corona of small lines, and marked transversely in the centre by a few irregular lines. The border is delicately striated as well as the margins of the canaliculi, and the centre of the interspace between two adjoining canaliculi is provided with a row of granules or denticules.

In this form, as in most of the *Surirellæ*, increase takes place at the two poles of the longitudinal axis.

The specific name has reference to the richness of the ornamentation which is found on the valves.

Surirella japonica, n. sp. (Plate X. fig. 8.)

Elliptica ; canaliculis radiantibus, brevibus ; area centrali lanceolata lineolis terminata, et nonnullis lineis curvatis irregularibus quandoque interruptis transverse signata ; margine et areolis interstitialibus striatis. Ad mare Japonicum.

This species, which was collected in the Sea of Japan, is very similar to the preceding. It is elliptical in form, but its canaliculi are somewhat shorter than those in *Surirella dives*. The extremities of the interstitial area are almost pedunculate, and are notably removed from the hoop of small lines which limits the central lanceolate areola. Moreover, the entire area between the canaliculi as well as the margin are delicately striated. The central area is much less elongated than that of *Surirella dives*, and it bears interrupted and somewhat curved transverse lines, which do not exist in that frustule.

Surirella argus, n. sp. (Plate X. fig. 9.)

Valvis ellipticis ; area centrali hyalina arcte lanceolata, irregulari et interrupto lineolarum ordine finita ; canaliculis constrictis, areolis interstitialibus granulo vel ocello signatis ; margine striato. In mari Japonico.

This frustule, which is also from the Sea of Japan, is provided with perfectly elliptical valves. Its centre presents a narrow area, which does not exhibit any distinct markings, and which is circumscribed by an irregular or interrupted series of small lines. Its canaliculi exhibit a notable contraction in the middle, and the small interstitial areolæ that result are each marked by a granule or ocellus. The margin is delicately striated.

Surirella ocellata, n. sp. (Plate X. fig. 7.)

Panduriformis ; superficie centrali tereti, a qua canaliculi procedunt ; margine et alis marginalibus striatis, spatiis interstitialibus ocello distinctis. Ad mare Japonicum.

This Diatom, which, like the preceding, was procured in the Sea of Japan, is panduriform in outline, and though somewhat large it is singularly elegant. It is not provided with a central area circumscribed by small lines; on the contrary, the centre is smooth, and from it spring the canaliculi that adorn the perimeter. The border of the valve as

well as its marginal alæ are striated, while each of the areas between the canaliculi is ornamented by a granule or ocellus.

Surirella multicostata, n. sp. (Plate X. fig. 6.)

Forma cuneata; area centrali hyalina lanceolato-cuneata, et lineolarum corona terminata; numerosis costulis vel canaliculis (58) radiantibus; margine et spatiis interstitialibus striatis. Ad Zebu.

This large cuneate valve, which was collected in the neighbourhood of Zebu, is provided with a smooth central lanceolato-cuneate area, which is circumscribed by irregular rows of small transversely disposed lines. It is distinguished by the possession of a corona of very numerous canaliculi or radiating costules. The marginal alæ, the interspaces between the canaliculi and the border, are delicately striated.

Surirella thaitiana, n. sp. (Plate XIX. fig. 3.)

Valva obovata, area lanceolata centrali transverse undulata, et lineolis terminata, canaliculis duplici ordine radiantibus ad verticem striatis; margine evidenter granulato. In portu Thaiti.

This elegant frustule was found in a rich collection made at a small depth at the port of Tahiti. It possesses an oval profile, and is provided with a central lanceolate area, which is circumscribed by a row of small lines, and also presents a few slight undulations. Its double row of medially constricted canaliculi are not separated by any interspaces, and the canaliculi exhibit at their extreme ends an incipient serrated striation. The margin is evidently granulated, and at its narrow extremity there are to be found a few canaliculi, which are hardly outlined, and which indicate the locality in which the increase of the Diatom occurs—a process which generally is bilateral and takes place at the poles of the valve.

Surirella grandiuscula, n. sp. (Plate X. fig. 5.)

Forma subovata, e majoribus; area hyalina centrali lineolarum ordine interrupto cincta; canaliculis inæqualibus per alas intercedentes et in alas marginales exeuntes distinctis; margine et alis striatis. In mari Pacifico.

This Diatom, which is of unusual size, was obtained in a sounding of great depth made in the centre of the Pacific Ocean. Its long axis measures not less than 196 μ., and it possesses a slightly ovate form with a large smooth central area, which is circumscribed by an interrupted irregular row of short lines. There is a circlet of large canaliculi, which become a little shorter and narrower as they approach the inferior or narrow extremity, and are separated by interspaces which terminate in marginal alæ. These alæ and the large border are striated, while, at the same time, a small group of striæ mark the centre of each intercanalicular space.

Campylodiscus, Ehrenb., Men.

As constituted by Ehrenberg and Meneghini, this genus embraced rotundo-elliptical forms with subradiate costules and canaliculi. By a greater development at the periphery than at the centre the frustule assumes a slightly tortuous aspect, and as this continues, the general aspect becomes more or less deeply curved, so as finally to resemble a saddle. The definition of the genus has been given by Pritchard [1] in the following words :—"Valves equidistant, frustules solitary, disciform ; disc tortuous or saddle-shaped, rotundato-elliptic, costate, costæ mostly radiate."

The tortuous form of the frustules renders it difficult to obtain correct figures of them, particularly from their zonal aspects.

In this genus, as in *Surirella*, the valves are surrounded by elegant submarginal wings, which become elevated on parting from the zone or girdle, a circumstance which has caused difficulty in the determination of species.

Campylodiscus japonicus, n. sp. (Plate XI. fig. 1.)

Forma subrotunda, grandis, costularum vel potius canaliculorum brevium circulo numeroso (fere 80) marginali cincta ; costulæ vel canaliculi a lineis spinulosis disseptæ, quæ dein evanescunt ; area hyalina centralis subrotunda. In mari Japonico.

This Diatom possesses the form of a large disc with a number of short radial costules or canaliculi. These are separated by lines of short "thorns," which occur on the connecting zone, and run centripetally from the extreme margin. There is also present a hyaline central subrotund area, which approximately coincides in shape with that of the entire frustule. The specimen was collected in the Sea of Japan.

Campylodiscus zebuanus, n. sp. (Plate XI. fig. 10.)

Forma mediocris subrotunda, costis ab area lineari axiali hinc inde radiantibus, medio angulariter curvatis. Ad Zebu, in mari Philippinarum.

This moderately large frustule was collected in the neighbourhood of Zebu in the Philippine Sea. It possesses a rounded outline and a smooth narrow almost linear central area, which runs along its axis. From the margin of this area radial costules run across the surface of the valve, and are folded along a line almost concentric with the edge. The two extremities of the central area terminate at two points, which may be called the poles of the frustule, and they seem to indicate two centres of development for the valve, as structures which appear to be rudimentary costules are perceptible in these regions. It is worthy of remark that when the developmental significance of these two points is recognised it is easy to understand how the valve may become more and more winding and ephippiform.

[1] *Op. cit.*, p. 798.

The specific name has reference to the locality in which the form was first collected.

Campylodiscus bicinctus, n. sp. (Plate XI. fig. 2.)

Valvæ subrotundæ, ephippiformes, duplici brevium costularum corona aream ellipsoideam includente. E mari Japonico.

This somewhat larger valve exhibits a large smooth rotundato-elliptical central area, which is surrounded by a double row of short radial costules, the rows being separated by a smooth narrow ring. As in the preceding case, the two poles present indications of the development of new costules.

The presence of a double row of enveloping costules has been made use of in naming this type.

Campylodiscus erosus, n. sp. (Plate XI. fig. 3.)

Valva discoidalis, ephippiformis, costis subradiantibus numerosis prope marginem circum divisis ad aream sublinearem terminantibus; costularum pars centralis evanescens et quasi usu attrita. Ad oras Japonicas.

The present frustule bears some analogy to that last described. It possesses a double corona of costules, of which those round the periphery are short, while those situated more centrally are three times larger than the former in the middle, but diminish somewhat irregularly towards the poles. The smooth central area is long and narrow.

From the circumstance that the intermediate parts of the inner series of costules are so slightly manifest as to appear as if they had been subjected to attrition, the specific name of *erosus* has been given.

Campylodiscus erosus, n. sp. var. nov. (Plate XI. fig. 5.)

We have here represented a frustule from the Sea of Japan, in which most of the costules of the inner series are represented by two oblong cellules. There can be no doubt that this is but a further stage of the attrition which is manifested in *Campylodiscus erosus*, so that nothing remains of the costules except the two extremities. Hence, although apparently very distinct characteristics are here found, these can only be regarded as possessing a varietal significance.

Campylodiscus lepidus, n. sp. (Plate XI. fig. 7.)

Forma subrotunda, mediocris; costulis circumradiantibus a corona irregularium lineolarum, quæ aream late ellipticam includit; costulæ lateraliter partim linea, partim spatio quadratim punctato circumscribuntur; margine granulorum linea signato, exterius spinuloso. In mari Philippinarum.

This exceedingly elegant frustule possesses a subrotund form. It is slightly folded, and has a series of long costules, which are, however, not quite half the length of the radius, placed regularly round the periphery. These originate from a granulated circular line which circumscribes a central smooth oval area. The costules are divided from one another throughout half of their length by a simple line; in their outer half they become constricted and are rounded at their extremities, being at the same time separated by finely granulated areas, ornamented by minute quadrately disposed points. The extreme edge of the valve bears a circlet of minute granules, and the margin is provided with short spines.

Campylodiscus humilis, n. sp. (Plate XI. fig. 8.)

Forma parva, flexuosa, ephippiformis; costulis vel canaliculis ab area sublineari radiantibus; costæ utrinque a linea centrali profunde inflexa. Ad insulas Philippinas.

This small form bears a great affinity to *Campylodiscus zebuanus*, from which, apart from a difference in size, it may be distinguished chiefly by the two following circumstances: (1.) It is far more elliptical than the latter, and (2.) the line of inflexion, instead of being but slight, is well-marked. Although it is not possible to determine the true specific value of these differences, the form now in question has been provisionally regarded as a distinct species.

Campylodiscus philippinarum, n. sp. (Plate XI. fig. 9.)

Mediocris, ephippiformis; crebris costulis (centum et amplius) in tres ordines inæquales irregulariter divisis, a quibus area subrotunda circumscribitur, medio punctulis raris quadratim dispositis vix perspicuis signata. Ad mare Philippinarum.

This frustule, which was collected in the Philippine Sea, possesses a disc of moderate size, which, by the flexion of two of its axes, appears somewhat quadrate in outline. It has a corona of numerous radiating costules, which are separated by an undulating line into two rows of unequal size, while the inner and larger is surmounted by a third row of short cellules. The large central area is ornamented by a number of minute scattered granules, which are arranged in a quadrate manner.

Campylodiscus orbicularis, n. sp. (Plate XVI. fig. 10.)

Valvis subrotundis vix flexuosis, area elliptica lævi lineolarum serie cincta; costulæ subradiantes (42) ad utrumque polum divisæ. In mari Japonico.

At first this form seems to be a variety of *Campylodiscus lepidus* (Plate XI. fig. 7), as both possess approximately radiating costules or canaliculi, and in the centre of both there is an oval hyaline area circumscribed by a series of small lines. The structure of the margin, however, is completely different in the two types. In the former the border is coarsely

and irregularly striated, and the intercostal areas are punctated; while in the latter, in addition to the intercostal quadrately arranged punctations, the margin is denticulated and ornamented with a distinct corona of minute granules. As serving still more conclusively to determine the independence of the two organisms, it may be noted that while the symmetry of the radial costules of *Campylodiscus lepidus* indicate that augmentation must go on all round the periphery, in the present frustule somewhat larger intercostal areas are found at the diametrically opposite points, so that it is manifest that increase takes place in these regions.

Campylodiscus oceanicus, n. sp. (Plate XI. fig. 4.)

Valvis flexuosis; costulis longiusculis, quorum apicibus cellulæ vel costulæ interponuntur; area centrali tereti subrotunda. In mari Pacifico.

This flexuous Diatom was collected in the Pacific Ocean. In it the radiate costules encircle a smooth and almost round area. At their summit these alternate with another order of costules, which seem to be elongated cellules. These are continued to the extremity of the submarginal wing, for which they form a support.

Campylodiscus nitens, n. sp. (Plate XI. fig. 6.)

Forma parva, flexuosa; costulis subradiantibus grandiusculis aream hyalinam limitantibus; costulæ superius rotundo-complanatæ brevi spatio veluti granulo terminato distinctæ. Ad Zebu, ex insulis Philippinis.

This small discoid form was collected in the neighbourhood of Zebu in the Philippine Islands. It is distinguished by possessing a series of subradiate costules, whose outer extremities are somewhat rounded, and separated from one another by small interspaces that are bounded by small round granule-like bodies, which more centrally are replaced by simple lines. In the centre there is a smooth area of moderate size.

Campylodiscus wallichianus, Grev., var. *thaitiensis*, nov. (Plate XVI. fig. 6.)

This magnificent frustule, of which several specimens were collected at the port of Tahiti, surpasses all the others in the elegance of its ornamentation. It consists of a large and slightly folded disc, the curve being reversed with respect to the two axes. Almost the entire surface is occupied by subradiating canaliculi, which terminate marginally in rows of distant erect spines. The canaliculi gradually disappear as they approach the centre, where a biconcave smooth area exists. Around the two rounded extremities of this area there are a number of more sharply defined punctations, the most external of which form a semicircle, a circumstance which serves to give greater prominence to the area in these regions.

On comparing this frustule with others previously known, it is found to be most closely

related to the *Campylodiscus wallichianus* of Greville ;[1] but it differs from the latter in its considerably larger size, its far greater number of canaliculi, and in the arrangement of its spines, which, in the Grevillean species, appear in the middle part of the lines only, and not throughout their whole length as in the form from Tahiti. Moreover, the central area of *Campylodiscus wallichianus* is linear, and is sharply defined round its entire margin, and not at the two extremities only as in the present case.

These points of distinction cannot, however, be regarded as essential, but depend merely on the greater or less number of certain details of structure in the two types, so that the Diatom now in question has been indicated merely as a variety of the Grevillean frustule.

Campylodiscus anceps, n. sp. (Plate XVI. fig. 2.)

Valvis rotundis, vix curvatis ; e maximis ; triplici granulorum circulo bis opposite interrupto, a quo plurimæ (64) brevissimæ costulæ dimanant. Ad Zebu in mari Philippinarum.

This is the most singular and novel form of *Campylodiscus* which has to be recorded. It possesses a large and almost perfectly spherical disc, which is bounded by a triple granulated margin, from which there proceed centripetally numerous short costules. At two diametrically opposite points the marginal bands are interrupted, and at these points small embryonic costules occur. By means of oblique illumination it may be seen that the internal border of the rim is very finely striated, while the centre is devoid of ornamentation of any kind. It is also noteworthy that, contrary to what occurs in all other known species of the genus, the valve is almost smooth. It differs too from the other species by the absence of marginal wings ; but the non-existence of these is explained by the all but entire absence of a valval curvature.

This curious frustule might be regarded as presenting a transition to the genus *Coscinodiscus*, were it not for the diametrically opposite areolæ that occur upon its rim, where augmentation takes place, and in this respect it approaches nearer to the genus *Surirella*.

The diameter of this novel form is 170 μ.

Nitzschia, Hassall, W. Sm.

The genus *Nitzschia*, which was instituted by Hassall in 1845 in memory of one of the first observers who called the attention of naturalists to the great family of the Diatomaceæ, embraces the free compressed more or less bacillar frustules, whose linear keeled valves are provided with one or more longitudinal lines of puncta, the keel being often excentric. This last character is sufficient to distinguish it from the genus *Amphi-*

[1] This frustule is figured in Schmidt's Atlas, pl. xiv. figs 15. and 16.

prora, while the general characters of the shell prevent it from being confounded with the *Synedræ*.[1]

The *Nitzschiæ* are abundantly represented, both in freshwater and in marine collections; but in the latter case they especially belong to the littoral flora, a circumstance which sufficiently explains the fact that observers have in recent times failed to meet with so many new species of this genus as in the case of many others which do not flourish so abundantly in the neighbourhood of the sea-shore. Among the numerous soundings made by the Challenger in different localities many species of the genus were recognised, but of these only the following are worthy of special attention:—

Nitzschia plana, W. Sm., var. *zebuana*, nov. (Plate XIII. fig. 10.)

This specimen greatly resembles the *Nitzschia plana* of Smith[2] when its outline is considered, although its extremities can hardly be called acute. Its valve is obscurely striated, while the keel, instead of bearing a single band of larger granules, is marked at intervals by small irregularly disposed but very prominent lines. It is also to be borne in mind that the species of Smith is a brackish-water form, while the present frustule is marine, having been collected in the canal of Zebu among the Philippine Islands. Notwithstanding these differences the latter must be viewed as only a variety of the former, especially when the great resemblance of the two forms and the identity of the interrupted striation of the two valves is kept clearly in view.

Nitzschia obesa, n. sp. (Plate XIII. fig. 11.)

Duplo longior quam latior; medio angulariter constricta; apicibus obtusis; striis dense decussatis; carina lata distinctioribus lineolis inordinate signata. In mari Philippinarum prope Zebu.

This form, which is also from Zebu, is remarkable in being only twice as long as it is broad. It is angularly constricted in the middle, its extremities are obtuse, and the striæ are densely decussate. The valve is flanked by a large keel, which is traversed by prominent lines of irregular distribution and direction.

Nitzschia obesa, n. sp., var. nov. (Plate XIII. fig. 13.)

We have here represented a frustule from the port of Tahiti, which is somewhat less obese than that just described, and which is provided with somewhat cuneate extremities. Its striation, however, is of equal delicacy, and the keel though narrower bears short but equally prominent lines. From such characteristics it can only be looked upon as possessing a varietal importance.

[1] See Pritchard, *op. cit.*, p. 779. [2] Synopsis of the British Diatomaceæ, vol. i. p. 42, pl. xv. p. 114.

Nitzschia vermiculata, n. sp. (Plate XIII. fig. 12.)

Magna, triplo longior quam latior; latere carinali per constrictionem angularem bilobato; carina granulis distinctioribus medio signata; apicibus cuneato-obtusis; valvis vermiculatim striolatis. Ad Zebu.

This superb Diatom was collected in the channel of Zebu among the Philippine Islands. Its frustule, which is three times as long as broad, is angularly constricted in the middle, and presents a bilobed aspect, the lobes forming wide curves. It is also marked by a row of large granules, and the extremities of the valve are cuneately obtuse. The general valvular ornamentation occurs in the form of tortuous lines of granules which intersect each other.

Nitzschia mammalis, n. sp. (Plate XXIX. fig. 5.)

Mediocris, oblonga, sinuato-constricta; apicibis productis, mammiformibus, carina excentrica; striis transversis. In mari Arafura.

This frustule, which was obtained in the Arafura Sea, has an elegant oblong form and a deep central contraction. Its transverse striation is uninterrupted longitudinally, and its extremities are slightly prolonged and mammiform.

Bacillaria, Gmel.[1]

When the movements of Diatoms are considered, the peculiarities presented by those of the genus *Bacillaria* are the most remarkable and mysterious of any. The genus includes forms which are generally united to one another laterally, and in great numbers, and in the living condition the individual frustules are constantly gliding over one another without ever becoming completely disunited. Although various hypotheses have from time to time been advanced to explain such wonderful phenomena, no observer has been able by the most ingenious methods, by the use of the most perfect object-glasses or the most efficient methods of illumination, to discover any special organs that might bring about such curious results.

When, by treatment with acids or by mechanical action, the frustules of the *Bacillariæ* become isolated from one another, their form may at first sight cause them to be confounded with species of *Synedra*, *Diatoma*, or *Nitzschia*. Yet in the case of surface gatherings it is easy, by placing the organisms in a glass cell before isolating the frustules by the action of heat, to distinguish them by the characteristic disposition of the frustules already referred to.

By this means Bacillarian forms were frequently recognised in surface gatherings made in the Sea of Arafura. The frustules were sublinear, lanceolate, and very slightly sigmoid.

[1] This genus was established by Gmelin in 1788 when he founded the species *Bacillaria paradoxa* (Linnæus, Syst. Nat., ed. xiii. vol. vi., 1788; Hassall, Freshwater Algæ, pl. xciii. fig. 10; Kützing, Bacill. pl. xxi. fig. 18; Smith, Synop. Brit. Diat. vol. ii. p. 10, pl. xxxii. fig. 279, suppl. pl. lx. fig. 279.

Their apices were very acute, and the valves finely striated, while they were at the same time surrounded by a row of small granules or lines similar to those which occur in the *Nitzschiæ*.

Bacillaria socialis, Greg., var. *indica*, nov. (Plate XXV. figs. 9 and 10.)

The known species of *Bacillaria* are few, and amongst these Pritchard (*op. cit.*, p. 784) records as *Bacillaria socialis* a form determined by Gregory[1] as *Nitzschia socialis*. On comparing this frustule with those from the Arafura Sea they are found to agree (1.) in having their valves of a linear-lanceolate form ; (2.) in being ornamented with a very fine transverse striation ; and (3.) in presenting acute apices ; while they differ in the following respects : (1.) The Arafuran frustules are slightly sigmoid, while the others do not exhibit this peculiarity ; (2.) the presence of a central keel, mentioned by Gregory as occurring in his Diatom, is not to be detected in the present case, in which there is (3.) a band of granules which are somewhat more distinct and more sparsely distributed than the striæ.

Although, in the absence of an authentic preparation of Gregory's species for purposes of more accurate comparison, it is not easy to determine the true significance of the above-mentioned points of difference between what are otherwise two closely allied forms, the frustules now figured have in the meantime been regarded as a variety of his typical form.

TRIBE III.—CRYPTORAPHIDIEÆ.

Rhizosolenia, Ehrenb.

Judging from the various definitions that have been given of this genus, which was first introduced by Ehrenberg,[2] it does not appear to have been clearly understood hitherto by any observer. The definition given by Pritchard in his History of the Infusoria (p. 865) is as follows :—"Filamentous, frustules subcylindrical, greatly elongated, siliceous, annulate ; annuli broadly cuneate ; surface striated, extremities calyptriform, pointed with a bristle." In the Micrographic Dictionary, on the other hand, the following generic characteristics are pointed out :—"Frustules elongate, subcylindrical, marked with transverse spiral lines, ends oblique or conical, and with one or more terminal bristles." But these definitions cannot be said to correspond more accurately to the reality than that proposed by Ehrenberg himself, which, according to Pritchard, was as follows :—"Lorica tubular, with one extremity round and closed, while the other is attenuate and multifid as if terminating in little roots."

It is not easy to understand why it was not recognised from the beginning that the

[1] *Trans. Micr. Soc. Lond.*, vol. v. p. 80, pl. i. fig. 45.

[2] Ehrenberg, Mikrogeol., plates xviii., xxxiii., and xxxv.

cuneate hoops, which are seen in some species, and the spiral line, which is still more frequent, result simply from the form of the distinct parts, which by their union constitute the tube of the Diatom. That these frustules are composed of several parts that are more or less liable to be detached from one another—a phenomenon which may also be witnessed in the case of the numerous hoops of *Rhabdonema*, *Striatella*, and such like forms—can hardly be doubted. The parts that form the tubular walls, instead of being like those of the hoops, are generally somewhat rhomboidal or lozenge-shaped, and in some species, *e.g.*, *Rhizosolenia robusta*, Norman, these, having two sides of the parallelogram extremely long and united by means of two shorter sides, form a belt which is terminated by two transverse lines. In other species every constituent part is exactly rhomboidal and equilateral, while they are bent round and united together in such a manner that they form a tube upon which the lines of suture appear to be arranged in a spiral manner. Very frequently the sides of each rhombus are somewhat curvilinear, and the obtuse angles truncated, yet they fit together in such a manner as to constitute a tube.

Among the *Rhizosoleniæ*, which were found frequently to abound in many surface gatherings made by the Challenger, frustules were often observed in a broken condition on account of their size and the relative tenuity of their walls, and in such cases the rhomboidal parts of which they were composed were frequently isolated from one another, while at the same time the sutural lines could be distinguished. It must also be recorded that in some species the rhomboidal plates were found to be very small, so that the perimeter of the tube was formed of several plates, and in such cases (see Plate XXX. figs. 11 and 14) the surface of the Diatom resembled the skin of a fish or of a serpent.

The genus *Rhizosolenia* was always regarded as marine until Professor Hamilton Laurence Smith discovered his very singular *Rhizosolenia eriensis*[1] and subsequently *Rhizosolenia gracilis*, which more rarely accompanied the former, in a surface gathering made on Lake Erie in North America.

In marine gatherings the genus, in addition to its occurrence as a surface form, has also been recognised amongst the contents of the stomach and alimentary canal of Mollusca and other marine animals. In soundings, and still more in deposits, the *Rhizosoleniæ* can only be recognised by means of their mucrones, which, like a solid or massive substance, can resist the trituration and pressure that invariably reduce their thin walls to very minute and unrecognisable débris.

Another feature of great importance, and one which has not hitherto been recognised, is well seen in some of the species that have now to be recorded, namely, the existence of a minute cavity towards the extremity of each frustule. This cavity—if it is not to be regarded as a consequence of the union—no doubt serves for the more perfect adhesion of the frustules, which are disposed in rows or series, as each corresponds in position to the extremity of the terminal region of an adjoining frustule.

[1] See figure in van Heurck's Synopsis des Diatomées de Belgique, pl. lxxix. fig. 9.

Rhizosolenia inermis, n. sp. (Plate XXIV. figs. 7, 8, 10, and 13.)

Annulis distinctis; striis ægre perspicuis; processu calyptriformi terminali truncato et lineola brevi longitudinaliter signato. In mari Antarctico.

The four cylindrical frustules here shown are composed of rings of trapezoidal plates, and terminate in oblique calyptræ. It is noteworthy that in all the terminal mucrones are absent, and that the extremities of the calyptræ are truncated, each being ornamented by a short longitudinal line, the whole reminding the observer of the shape of a pen. This line seems to represent the mucro which is peculiar to other Rhizosolenian species, a belief which is substantiated by the fact that in fig. 8 a trace of the line may be perceived in the cavity, which is so disposed as to receive the extremity of the succeeding frustule. It is therefore of the utmost importance to remark that in the definition of the genus the terminal mucro, *although a very general*, cannot be regarded as an *essential* characteristic. Although varietal differences may exist in the four frustules figured they have all been, for the sake of convenience, grouped under one specific name, which has been suggested by the common character of their extremities just alluded to.

Rhizosolenia polydactyla, n. sp. (Plate XXIV. fig. 2.)

Annulis brevioribus crebris; striis imperspicuis; processu calyptriformi brevi et acuto mucrone armato. In mari Antarctico.

This frustule is peculiar on account of the shortness and multiplicity of its rings. The terminal mucro is strong and very acute, even more so than is indicated in the figure.

The specific name of this Antarctic form is intended to be indicative of the remarkable character of its rings.

Rhizosolenia inæqualis, n. sp. (Plate XXIV. fig. 15.)

Forma subcylindrica, constans annulis transversis parallelis; processu calyptriformi composito, in acutissimum mucronem exeunte. In mari Sinensi ad Hong-Kong.

This Diatom was observed in a surface gathering which was made in the neighbourhood of Hong-Kong. It is remarkable on account of the inequality of its transverse diameters at different parts, an anomaly which may be attributed to regional inequalities of pressure on the rings, which, instead of being round, are oval in section. It is also especially noteworthy that the calyptriform process does not consist merely of a single piece, but is made up of two or three rings or distinct parts.

Rhizosolenia sima, n. sp. (Plate XXIV. fig. 11.)

Frustulis subcurvatis; calyptra brevi in obtusum brevissimum mucronem desinente; imperspicue striata. In extremo mari Antarctico ad glacies impervios.

A singularly strange aspect is presented by the present frustule, which cannot be regarded as an accidental or monstrous form, as it has been frequently met with in the

same collection. It is true that much significance cannot be attached to the arcuate curvature, which is here very manifest, but the small protuberant, massive, and almost spherical mucro forms a well-marked characteristic, and must be viewed as of specific importance.

Rhizosolenia sima, n. sp., var. nov. (Plate XXIX. fig. 9).

This form differs from the type, not merely by its size—a circumstance of little importance and attributable to pressure acting on the frustule—but rather in the construction of the terminal calyptra, which is not simple but formed by the union of several pieces.

Rhizosolenia japonica, n. sp. (Plate XXIII. fig. 7.)

Forma subcylindrica, annulata; annulorum divisione transversa; striis imperviis; mucrone terminali longissimo tenuissimo. In mari Japonico.

Only one specimen of this interesting type, which was obtained in the Sea of Japan, has been observed. It is characterised by its very long terminal mucro, a circumstance in which it perhaps does not differ from *Rhizosolenia styliformis*, Bright.[1]—and by the fact that its rings are divided transversely—a character which is not found in Brightwell's species. Although its minute characteristics have still to remain incompletely determined, it cannot be regarded as a teratological specimen, but must be looked upon as the type of a true species.

The organism shown in Plate XXIII. fig. 8, although bearing certain external resemblances to the *Rhizosoleniæ* in its general form and in the nature of its extremity, may not improbably ultimately be determined to be of an animal nature. The absence of any trace of division and of any indication of the origin of the mucro, as well as the presence of a very pronounced granulation, are opposed to its being regarded as a Rhizosolenian Diatom, while the fact that the specimen has been found in a preparation of fresh material made on board the Challenger has rendered it impossible to determine whether its walls are provided with or are devoid of siliceous matter.

Rhizosolenia murrayana, n. sp. (Plate XXIV. fig. 12.)

Cylindrica, constans partibus rectangularibus reticulatim dispositis, et convexe terminata, et mucrone terminali instructa. In mari Antarctico.

This very singular form presents an entirely novel aspect, yet possesses all the characters necessary to its being regarded as a member of the present genus. It has the form of a small cylinder, and is composed of a large number of distinct equal rectangular parts, which are cemented together, the tube being closed at both extremities by a convex

[1] *Micr. Journ.*, vol. vi. p. 94, pl. v. fig. 5; Norman, *Ann. Mag. Nat. Hist.*, vol. xx. 1857, p. 158; Schultze, *Micr. Journ.*, vol. vii. p. 18, pl. ii. fig. 1; Pritchard, *op. cit.*, p. 865, pl. vii. fig. 32.

portion surmounted by short sharp points. Although the extremities can hardly be called calyptriform, the generic determination that has here been given cannot be questioned, more especially as an abundant supply of siliceous matter has been proved to occur in its walls by subjecting it to a process of incineration.

Rhizosolenia imbricata, Bright. (Plate XXIV. figs. 1 and 1 *bis*.)

The form which is represented on Plate XXIV. fig. 1 under a magnifying power of 130 diameters, and at fig. 1 *bis* under a power of 640 diameters, belongs without doubt to the *Rhizosolenia imbricata* of Brightwell.[1] In connection with fig. 1 the unimportance of attaching any significance to the proportion between the transverse axis and the length of the frustule may be noted, and it may also be observed that in the middle of the granulated series of rings there occurs a smooth ring. Here it is probable that the process of division takes place, by the formation of a diagonally placed diaphragm, which arises in such a manner as to bring about the formation of two new calyptræ.

The arrangement of the moniliform striæ on the other rings is radiating, the radiation taking place outwardly from a median axial line. Each ring is flanked by two small triangular and similarly sculptured spaces, from which it may be inferred that the entire annulus is composed of two trapezoidal parts, on each of which the striæ run in different directions.

Plate XXIV. fig. 14, represents a form bearing on its calyptriform extremity two long and very acute mucrones. Whether this appearance is normal or teratological, or whether it is merely accidental—one mucro alone belonging to the frustule, the other being casually apposed—cannot be determined. Should further observations prove that both belong to the same Diatom, it must be regarded as a new species, but at present there is nothing to show that it is not a monstrous form.

Rhizosolenia robusta, Norman, var. nov. (Plate XXIV. fig. 5.)

Here there is shown the calyptriform extremity of a *Rhizosolenia*, which is remarkable on account of its extraordinary size and the sculpturing of simple radial lines which it presents. These characters coincide with those of *Rhizosolenia robusta*, Norman, which is figured in Plate viii. fig. 42 of Pritchard's History of the Infusoria. The form of the latter, however, unlike that of the former, is compressed, and its mucro is described as being "short, delicate, and nearly linear," instead of being short and cuneato-acute, as in the present case. Yet these points of difference cannot be regarded as possessing more than a varietal significance.

The parts entering into the composition of the rings of this variety are sub-rectangular.

[1] *Micr. Journ.*, vol. vi. p. 94, pl. v. fig. 6.

Rhizosolenia (?) flaccida, n. sp. (Plate XXIX. fig. 4.)

Cylindrica, annulata, parietibus tenuissimis firmitate destitutis; annulis brevibus parallelis. In mari Adriatico et Arafura.

Among the surface gatherings which have been made at intervals for some years past in the Adriatic, I have observed the frustule here figured from a form found on the surface of the Arafura Sea. It possesses a delicate structure, being bounded by two nearly parallel longitudinal lines, and crossed by transverse parallel lines, which are disposed at approximately equal distances from one another. Towards each extremity there is an irregular circle, whose diameter is to that of the frustule in the ratio of two to three. These circles are the extremities of the tubular organisms, and, like the parietes, are so thin that when dried on a glass they collapse. It may be noted, however, that the parietes, though very delicate, contain siliceous matter, as they resist exposure to a red heat.

Although the tubuliform part of this interesting organism bears a resemblance to the *Rhizosoleniæ*, no calyptriform extremities have ever been observed, hence its true generic position cannot be determined with certainty. It can only be examined when mounted in the dry state.

An organism which is pretty abundant in the surface of the Sea of Arafura is shown in Plate XXIX. fig. 8. It is of ovoid form, and terminates at one of its slightly prolonged extremities in a small flat circular area, from which a strong solid conical point arises. At its opposite extremity an opening is seen, which doubtless serves for the reception of the salient extremity of the succeeding frustule. The parietes are slightly and indistinctly striated, but the small terminal circle is surrounded by short but somewhat more protuberant lines. Although the appearance presented by the pointed extremity recalls the calyptra of a *Rhizosolenia*, it is at present impossible to determine whether the organism really belongs to this genus or is a sporangial form. It is clear, however, that it is a normal form, as many similar specimens have been observed.

Rhizosolenia arafurensis, n. sp. (Plate XXX. fig. 12.)

Frustula cylindrica, non annulata; parietes partibus subtrapezoidalibus compositæ; calyptra desinit in elongatum, obtusum, tubularem mucronem; striæ imperviæ. In mari Arafura.

Although in all other recent and fossil *Rhizosoleniæ* the terminal mucrones are solid, the form shown at fig. 12 has this part tubular and obtuse. The frustular walls are composed of subtrapezoidal pieces, the separating quasi-sutural lines being merely thinner and more transparent strands. The striæ ornamenting the various parts are exceedingly delicate, but their presence is argued by the slight tint that may often be recognised under the microscope.

On Plate XXX. figs. 11 and 14, two other forms of *Rhizosolenia* are represented, in

both of which many scale-like parts go to form the circumference of the tubes. These parts are in both somewhat irregularly quadrate in outline, but they are relatively much broader in fig. 11 than in fig. 14. As in the case of *Rhizosolenia arafurensis* only fragments have been observed.

Dactyliosolen, n. gen.

In a tow-net, which was wrought on the surface of the Antarctic Ocean on March 3, 1874, lat. 53° 55′ S., long. 108° 35′ E., some interesting forms, akin to the *Rhizosoleniæ*, Ehrenb., were collected. In both the form of the frustules is cylindrical, and in both it is composed of plates of trapezoidal outline—the *Dactyliosolen* cylinder (Plate IX. fig. 7) being manifestly the result of the union of a series of hoops, which, if detached along the lines of suture and spread out on a plane, would present long linear profiles terminated by oblique parallel lines. But, on the other hand, in *Dactyliosolen* there is no trace of the calyptriform extremities, which are essential to the *Rhizosoleniæ*, so that it cannot be ascribed to the latter genus. Apart, however, from this circumstance, it is of importance to observe that at intervals in the course of the filament *hyaline belts* occur. Each of these seems to be a terminal belt of union between the various frustules, any adjoining pair being separated by a space equal to about one-tenth of the diameter of the frustule. It is also to be remarked that at the lines of junction a few incipient granules or denticules may be perceived, and it is very important that the cellules, which ornament the component rings of two adjoining frustules, stand on the opposite and not on the corresponding margins of the rings.

That the combination of such characters is sufficient to warrant the establishment of a new genus must be admitted, and it has been named *Dactyliosolen*[1] from the circumstance that the perfect tube is composed of a series of rings or hoops.

Dactyliosolen antarcticus, n. sp. (Plate IX. fig. 7.)

Forma cylindrica; frustulum compositum ex pluribus annulis cellulatis; cellulis linearibus oblongis. In mari Antarctico.

This is the only species of the present genus that has yet been observed, and its characters are consequently those of the genus.

Chætoceros, Ehrenb.

The following is the definition of this genus given by Ehrenberg (*vide* Pritchard's History of the Infusoria, p. 861):—"Frustules without striæ, united with the adjacent ones by the interlacing on each side of awns proceeding from the frustule, or from a cingulum between the frustules, and so forming a filament."

A more exact and at the same time more concise definition is found in Lauder's

[1] δακτύλιος, a ring; σωλήν, a channel or pipe.

Memoir on the Marine Diatoms of Hong-Kong, annotated by Ralfs, and printed in the Transactions of the Microscopical Society, new series, vol. iv. It runs thus :—"Frustules smooth or minutely punctated, united with the adjacent ones by the interlacing of awns proceeding from the frustule."[1]

All the members of the genus *Chætoceros* are extremely fragile, so that it is very difficult to distinguish them in deposits, especially in marine mud, in which only the more robust forms are to be recognised, such as sporangial *Goniothecia*, *Dicladiæ*, or *Syndendria*. On the other hand, filaments of *Chætoceros* are much more abundant in surface collections, being perhaps even the predominant forms, and among those collected in the Challenger tow-nets, specimens belonging to the greater number of known species have been observed.

Chætoceros protuberans, Lauder, var. nov. (Plate VIII. fig. 2.)

That a form of the *Chætoceros protuberans* of Lauder[2] is here represented is indicated by the mammillar swelling on each valve, the outline of this protuberance being clearly seen in the oval space intervening between two adjacent frustules. This species is described by its founder as possessing minute bristly awns, but these are not to be observed in the present frustule, and on consulting the plate of the typical form given by Lauder minute bristles are only seen in connection with the terminal valves. If this is the normal condition the specific definition given must be regarded as imperfect. Since, however, the series of frustules represented in our plate may be incomplete, the precise differences between the two organisms cannot be definitely fixed, although the varietal character of the series at present in question may be provisionally accepted.

Chætoceros dispar, n. sp. (Plate VIII. fig. 6.)

Frustula compressa, in seriem per longas setas teretes connexa a valvis procedentes, et ad originem constrictas; valvis alterne concavis et subconcavis. In mari Antarctico.

This form shows several analogies to the *Chætoceros decipiens* of Cleve,[3] but no traces of striation or of punctation are to be found in the filaments or awns as in the allied type. Moreover, the awns arise, not from the angle of the frustule, but exclusively from the plane of the valve. At a short distance from their origin each filament presents a slight swelling, and one of the valves is always more concave than the other, a circumstance which has suggested the specific name.

This species was found in the Antarctic Ocean.

[1] This latter definition, which does not exclude punctated forms, again illustrates the necessity that frequently arises and that has already been referred to, for extending original definitions.

[2] Remarks on the Marine Diatomaceæ found at Hong-Kong, with descriptions of new species, *Trans. Micr. Soc. Lond.*, new series, vol. xii. p. 79, pl. viii. fig. 11, 1864.

[3] Diatoms from the Arctic Sea, *Bihang k. Svenska Vet. Akad. Handl.*, Band 1, No. 13, p. 11, pl. i. figs. 5 *a* and 5 *b*.

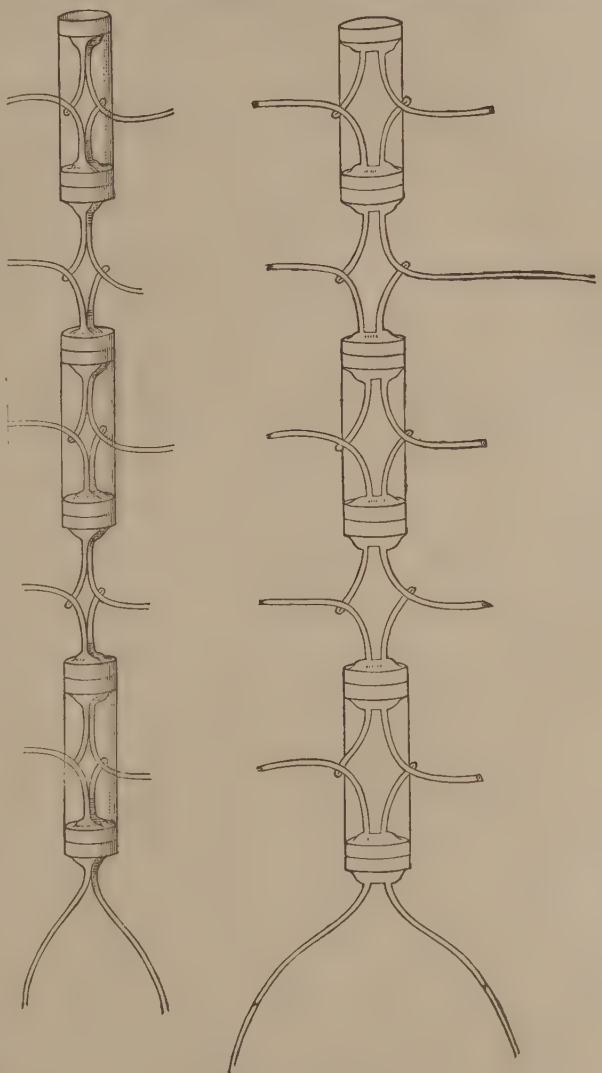
Chætoceros janischianum, n. sp.

Frustula cylindrica per cingulum binatim in laxam seriem conjuncta ; cornubus binis prolixioribus mediis valvis assurgentibus et eleganter curvatis. In mari glaciali Antarctico.

This is without doubt the most elegant type of the genus *Chætoceros*. It was gathered from the surface of the Antarctic Ocean in the form of long seriate frustules, which were united together in pairs by a common belt. The valves are oval and notably convex, and their awns, which are very long and smooth, originate from their centre, proceeding first almost at right angles to the surface of the valve, and afterwards interlacing by an elegant curve with the corresponding awns of an adjoining frustule. Where this interlacing occurs the awns are curved horizontally and bent in such a manner that each is alternately prolonged in a direction at right angles to the plane of the other. At the inferior valve of the terminal frustule the two setæ are somewhat shorter, and are symmetrically curved downwards.

The belt already alluded to is siliceous, and its presence is difficult to reconcile with the independence of the two frustules, nor is it easy to imagine how it can disappear, and so leave the latter free.

The species has been named in honour of Mr Janisch the well-known Diatomist.



Chætoceros ianischianum, n. sp.

Chætoceros curvatum, n. sp.

Frustula solitaria ; valvis ovalibus, curvatis, superiori convexa, inferiori concava ; satis a medio valvarum utrinque inferius curvatis, brevioribus ; zona quadruplo transverse longior quam latior. Ad meridiem insulæ Heard.

This isolated frustule possesses four awns or cornua, originating from the centre of the concavo-convex valves. Those from the externally concave or inferior valve are slightly tortuous, while all are short, and bent downwards. The zonal side is about four times as long as broad.

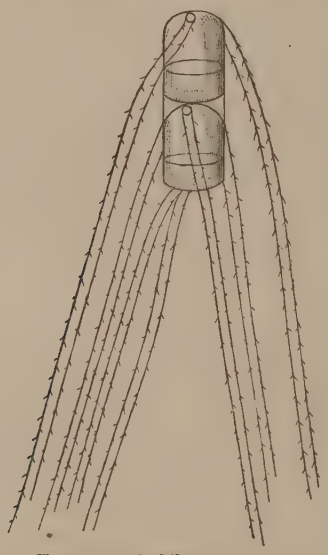
Chætoceros curvatum, n. sp.

The specific name has reference to the curvature of the valve.

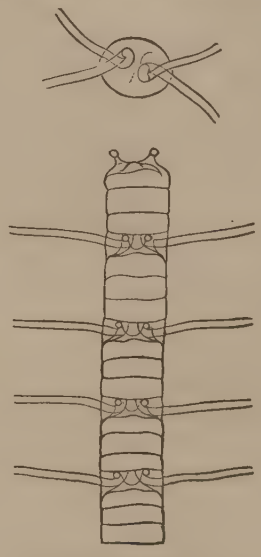
Chætoceros criophilum, n. sp.

Frustula oblonga, valvis convexis (superior inferiori convexior); setis spinulosis longissimis a mediis valvis orientibus, et inferius curvatis. In mari Antarctico.

In this Diatom it is to be noted that the two valves differ from each other in two important respects: (1.) The height of the upper seems to be double that of the lower; and (2.) the upper valve is decidedly more convex than the lower. The setæ are very long, spinulose, spring from the middle of the valves, and are slightly curved near their origin. In the course of their length they are ornamented with sparsely and somewhat irregularly disposed apiculi, all of which are directed towards their distal extremities.



Chætoceros criophilum, n. sp.



Chætoceros convolutum, n. sp.

This species was gathered near the ice-barrier of the Antarctic Ocean.

Chætoceros convolutum, n. sp.

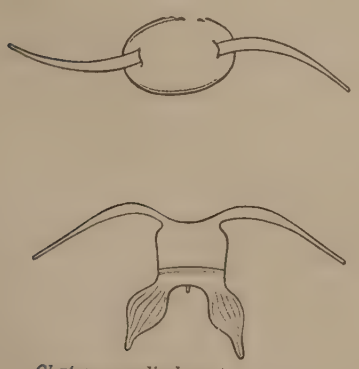
Valvis ovalibus, una convexiuscula, altera plana; setis longissimis a media valva convolute orientibus. In mari Antarctico inter insulas Kerguelen et Heard.

This Diatom was obtained in a surface collection made in the Antarctic Ocean between Kerguelen and Heard Islands. The frustules are subquadrate, and arranged in a series. The valves are oval, the one being convex and the other flat. The setæ originate in the centre of the valve, and, after curving round each other, diverge horizontally. In the figure only two awns are seen between two adjoining frustules, the remaining two being either broken off or shortened. On the terminal valve the setæ are seen in an embryonic form as a pair of short protuberances. At their origin they are always convolute, a characteristic which is referred to in the name of the species.

Chætoceros radiculum, n. sp.

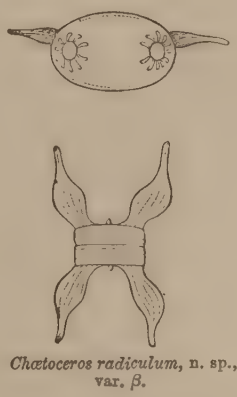
Frustulum solitarium; valvis ovatis, bino processu submarginali, inflato, costulato, brevi. Ad meridiem insulæ Heard.

This very puzzling form was collected to the south of Heard Island in the Antarctic Ocean. It is always solitary, and its setæ, instead of extending in a long line, form short swollen appendices, like bulbous roots, which are to a greater or less extent marked by longitudinally directed costæ that sometimes have their origin on the plane of the valve. To increase the difficulty of fully understanding this type it is to be noted that in addition to two setæ or cornua of the form just described there are in some cases



Chætoceros radiculum, n. sp., var. *α*.

Chætoceros radiculum, n. sp.



Chætoceros radiculum, n. sp., var. *β*.

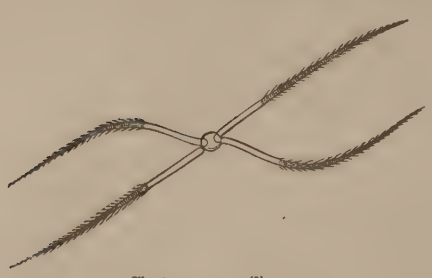
protuberances, which are twice as long, but are provided with less pronounced swellings, and are devoid of costæ. Such forms may be provisionally characterised as constituting variety *α* of the typical species. In a second group—variety *β*—there is found a transversely striated median zone and a single median projecting knob between each pair of large bulb-like marginal protuberances. Whether these differences from the typical species are to be regarded as varietal or as indicative of so many distinct species it is difficult to decide, although probably the former view is the more correct, and has been here adopted.

The small but distinct projecting processes which are sometimes present in the centre of the valves have also been regarded as having but a varietal significance.

The specific name which has been adopted, will serve to remind the observer of the curious form of the setæ or processes.

Chætoceros, sp. (?) nov.

The annexed woodcut represents a *Chætoceran* valve with long denticulate awns, but hitherto insufficient material has been observed to enable a complete account to be given of its specific characters. It must, therefore, be indicated as a doubtful species. It was obtained in a surface collection made to the south of Heard Island.



Chætoceros, sp. (?) nov.

Chætoceros incurvum, Bail., var. *umbonatum*, nov.
(Plate XXIX. figs. 10 and 16.)

An examination of the contents of the alimentary tube of two Echini dredged in the North Atlantic at Station 47, from a depth of 1340 fathoms, revealed the presence of numerous Diatoms, which were no doubt serving as food to the animals in question. One of the most frequent of these was the very small *Chætoceros* shown in the present figures. Its oval valves are provided with short recurved filaments, and the frustules are never found in series. Hence the entire genus *Chætoceros* may be divided into two sections, namely—(*a.*) *Chætocerotidæ gregariæ*, comprising all those forms that occur in chains, and (*b.*) *Chætocerotidæ solitariæ*, embracing all free species—as, *e.g.*, *Chætoceros radiculum*, and the form now before us.

The chief point of distinction between this form and *Chætoceros incurvum*, Bail.,[1] consists in the notable swelling at the centre of the valve which is to be found in the former. This, however, can hardly be regarded as a difference of specific importance.

In the genus *Chætoceros*, I include three genera established by Ehrenberg,[2] namely—*Dicladia*, *Goniothecium*, and *Syndendrium*. These have from the first presented great difficulties, and, in the words of Brightwell,[3] "much must yet be brought to light before a satisfactory classification of this group can be effected." The uncertainty in connection with them is owing to the fact that they have hitherto only been observed in a fossil condition in deposits, so that it has been found impossible to understand their form when in a state of actual vegetation sufficiently well to enable the observer to ascribe to them their proper place in a system of classification.

[1] *Micr. Journ.*, vol. iv. pl. vii. figs. 9–11.
[2] Ehrenberg, Mikrogeologie.
[3] *Quart. Journ. Micr. Sci.*, vol. iv. p. 105–109, pl. vii.

It has already been observed that in some living species of *Chætoceros*, *Goniothecia* in embryonic stages occurred, and for this reason Brightwell,[1] by analogy, has maintained that the three above-named genera are not organisms *per se*, but dependent and subordinate parts of species of *Chætoceros*.

In confirmation of this conclusion, I have repeatedly observed conditions such as are represented on Plate XIX. figs. 7 and 8, in which there may be seen frustules of *Dicladia capreolus*, Ehrenb.,[2] enclosed in frustules of *Chætoceros*, and as no substantial difference is found between *Dicladia* and *Syndendrium*, the non-independent character of these genera is manifest. But what can be the significance of this singular organic siliceous body enclosed in a Diatom cell, and itself constituting another cell? It would seem as if its sporangial nature was beyond doubt, and it must accordingly be regarded as designed for the reproduction of the species.

This interpretation of the so-called *Dicladia*, *Goniothecium*, and *Syndendrium*, is a confirmation of the opinion of Dr Wallich, who, instead of, like some others, viewing the sporangial frustule as a means of restoring to its original dimensions a Diatom which had been diminished in size by successive divisional processes, viewed it not as a normal and independent organism, but as a transient monstrous form designed for the elaboration of sporules or embryonal forms, and therefore capable of reproducing the species.

"In fact it had been observed that every species, by the process of conjugation, must be represented under two forms, one large and the other small, between which a gap exists, over which we have at present no means of bridging except by supposing that the two halves formed in cell division need not always be equal, and that by dwindling away through a succession of steps of this kind, the progeny of the sporangial frustules may be reduced to the original size." But that this does not happen may be shown by recalling what takes place in *Cocconema*, Ehrenb., in a collection of which it is easy to observe the sporangial, accompanied by the normal and much smaller form, without being able at the same time to recognise the gradual diminution of the frustules by which the extreme dimensions are reunited. (See vol. i. pl. xxiii., and vol. ii. pl. C, Synopsis of the British Diatomaceæ.) Moreover, the same fact is shown in a still more convincing manner by an observation made by Prof. Hamilton L. Smith on the *Stauroneis gracilis* of Ehrenberg.[3] This well-known naturalist recognised that the sporangial form is the same as that which Ehrenberg called *Stauroneis phœnicenteron*[4]—a type which greatly differs from the former in the delicacy of its striation, so that, instead of being regarded as a specific and independent form, the latter must be looked upon as but a transitory reproductive form of *Stauroneis gracilis*, Ehrenb.

[1] Brightwell, *Quart. Journ. Micr. Sci.*, vol. iv. pp. 105–109, pl. vii. figs. 53–60.

[2] Ehrenberg, Mikrogeologie, pl. xxxv. A. 17, fig. 8.

[3] Ehrenberg, in Kützing's Bacill., pl. xxix. fig. 3; Smith, Synopsis of the British Diatomaceæ, vol. i. p. 59, pl. xix. fig. 186.

[4] Kützing's Bacill., pl. iii. fig. 53; = *Navicula phœnicenteron*, Ehrenberg Infus. pl. xiii. fig. 1; Smith, *op. cit.*, vol. i. p. 59, pl. xix. fig. 185.

Chætoceros dicladia, n. sp. (Plate VIII. fig. 1, and Plate XIX. figs. 7 and 8.)

Frustulis in latere zonali transverse triplo longioribus, undulatis, in series per spatium medio constrictum divisis; quæ binis utrinque cornubus breviusculis subclavatis quater costatis connectuntur, setarum costis spinulosis. Inter Kerguelen et Heard.

The species of *Chætoceros* in which specimens of *Dicladia capreolus*, Ehrenb., have been repeatedly observed, was often found in gatherings made between Kerguelen and Heard Islands, near the polar ice-barrier in the Antarctic Ocean.

The frustules have their zonal sides three times as long as broad, while the transversely directed bounding line is undulating, so that an oblong space with a central contraction is left between the adjoining frustules. The setæ, which spring from the surface of the valve, are somewhat short, and are provided with somewhat club-shaped outer extremities which bear four thorny ribs.

Bacteriastrum, Shadb.

This very remarkable genus was instituted by Shadbolt in 1860 to embrace several curious small sun-like organisms, which are surrounded by a few radiating protuberances of considerable length, and which are very often met with in the stomach of Mollusca. Shadbolt defines his genus in the following words:[1]—"Frustules awned, united into a jointed conferva-like cylindrical filament, valves discoïdal, with marginal radiating awns."

Although there is a great analogy between the present genus and *Chætoceros*, I am of opinion, notwithstanding the opposite view of Professor H. L. Smith, that the differences are sufficient to warrant the preservation of both, apart altogether from the less important question already referred to of the desirability of avoiding too great multiplication of the species belonging to any given genus. Among these differences may be noted the following:—(1.) In *Bacteriastrum* the valves are always perfectly round, while in *Chætoceros* they are generally oval; (2.) in the former there is a greater number of awns, which always radiate round the border, than in the latter; and (3.) in seriate *Chætocerotidæ* the frustules constantly interlace by the alternate crossing of the awns—a character which is not found in *Bacteriastrum*.

Only a few species belonging to this genus are yet known, and these were diminished when Lauder,[2] after observing that *Bacteriastrum curvatum*, Shadb., constantly terminated the series of *Bacteriastrum furcatum*, Shadb.,[3] united the two forms under the name of *Bacteriastrum varians*. This important observation, however, increases the difficulty of determining the exact limits of specific forms, and, although among those

[1] Pritchard, *op. cit.*, p. 863.

[2] *Trans. Micr. Soc. Lond.*, new series, vol. xii. p. 7, pl. iii. figs. 1–6, 1864.

[3] = *Actiniscus sexfurcatus*, Ehrenb., Mikrogeol., pl. xxxv. B. 4, fig. 15; *Actiniscus biseptenarius*, Ehrenb.; *Actiniscus bisoctonarius*, Ehrenb., *loc. cit.* See also Pritchard, *op. cit.*, p. 863, pl. vi. fig. 26; *Trans. Micr. Soc. Lond.*, vol. ii. pl. i. figs. 1 and 2.

new forms which have now to be recorded from the Challenger collection, some may ultimately be found not to be specifically distinct, but to be different conditions of a species already known, distinctive names have been provisionally applied in all cases where the forms differ notably from one another, or from any hitherto recorded member of the genus.

Bacteriastrum brevispinum, n. sp. (Plate XV. fig. 8.)

Valvæ setis submarginalibus, numerosis (29) brevibus, lævibus, cuneatis, rectis. In mari Sinensi ad Hong-Kong.

This species occurs abundantly in surface gatherings made in the neighbourhood of Hong-Kong. It has the form of a large round hyaline disc, which is surrounded by numerous (twenty-nine) short, straight, radiately disposed, and gently cuneated thorns or setæ. These setæ cannot be regarded as the representatives of longer filaments that have become accidentally abbreviated, as their outermost extremities do not present the appearance of any truncation.

The specific name that has been applied has reference to the shortness of the spines.

Bacteriastrum brevispinum, n. sp., var. nov. (Plate XV. fig. 6.)

From the same locality the form represented in the present figure was obtained. It may be distinguished from the preceding by its smaller size, by being furnished with only ten radiating setæ, and by having the centre of the valve ornamented by a single granule, which may probably indicate that it has been terminal. Notwithstanding these differences, however, it can only be regarded as possessing a varietal significance.

Bacteriastrum wallichii, Ralfs, var. *hispida*, nov. (Plate XXIII. fig. 3.)

This frustule cannot be viewed otherwise than as a variety of *Bacteriastrum wallichii*,[1] Ralfs, which is provided with "smooth, simple, divergent awns." In the Challenger form, on the other hand, the awns are not smooth, but are provided with manifest apiculi. This circumstance may be recalled by the varietal name *hispida*, which has been proposed for this interesting form from the Arafura Sea.

On Plate XXIX. fig. 6, the same variety is represented from the neighbourhood of Hong-Kong.

Bacteriastrum spirillum, n. sp. (Plate XIX. fig. 2, and Plate XXIX. fig. 1.)

Setis submarginalibus tubulosis et spinularum spira decoratis. In mari Arafura.

The present figures show what is probably the terminal valve of the same species, of which perhaps they are two varieties. The curves of the awns in the one are slight and in

[1] = *Chætoceros bacteriastrum*, Wallich, *Micr. Journ.*, vol. viii. pl. ii. figs. 16 and 17; Pritchard, *op. cit.*, p. 863.

the same plane as the valve, while in the other the awns are flexuous, being first bent downwards and then curved round. The circumstance that one valve possesses a single central granule, while the other has several small irregularly distributed granules, is unimportant, but it is a matter of greater significance that in both the awns are not filiform, and that in both they are adorned by elegant spirals of very small apiculi, which give a singular appearance to the valves. In contradistinction to the last-named characteristic, it may be noted that in *Bacteriastrum varians*, Lauder, the awns are filiform and smooth.

Bacteriastrum varians, Lauder, var. *princeps*, nov. (Plate XIV. fig. 2, and Plate XXIX. fig. 3.)

This interesting form occurred in the rich gathering made on the surface of the Sea of Arafura, an intermediate frustule being shown in Plate XIV. fig. 2, and a terminal frustule in Plate XXIX. fig. 3. The former possesses the singularity of having the two filaments into which each ray bifurcates different from one another, the one being slightly arcuate and the other spirally bent, while the disposition of these filaments is such that the curved always alternate with the spiral. The latter has the rays undulating and slightly curved in the same direction. The rays of the terminal frustule do not arise from the perimeter of the valve, but somewhat more centrally, a circumstance which indicates that the valve is somewhat convex; moreover, a single central granule is very distinctly seen in this case.

Although the association of such characters gives the entire series a somewhat peculiar appearance, the present singularly distinct and elegant forms cannot be regarded as specifically distinct from *Bacteriastrum varians*, Lauder, from which indeed they differ only with regard to the condition of the rays.

Bacteriastrum varians, Lauder, var. nov. (Plate XXIII. fig. 1.)

Another new variety of Lauder's typical form is here shown under a magnifying power of 460 diameters. The round central area is entirely devoid of ornamentation, but near the periphery eleven stout rays project round the central disc. These rays are approximately at a uniform distance apart, and at their origin are somewhat swollen, a slight involution of the proximal bounding line of the ray occurring here just in the line of the longitudinal axis of the rays. At their distal extremities the rays bifurcate, the main shaft of each having, however, a length considerably greater than the diameter of the central disc. The branches of each bifurcation are bent in a graceful curve towards one another; their diameter is somewhat less than that of the main shaft, and their length is somewhat less than the radius of the disc. Where the bifurcation takes place a short, straight, but well-defined line runs down the shaft of each ray for a short distance. The almost perfect uniformity of the diameter of the rays from their origin to the point of bifurcation is especially noteworthy.

Corethron,[1] n. gen.

The new forms upon which this genus is established are exclusively Antarctic. They have a more or less cylindrical form, and are terminated by hemispherical surfaces, the base being surrounded by a corona of awns, which are more or less thick and long, and are smooth or thorny. Although from the rarity of these interesting organisms it was not possible to determine their siliceous or non-siliceous character by means of acids, this determination was made by the application of strong heat for a protracted period. This produced no visible change on their form, so that their diatomaceous nature could not be doubted.

Although the presence of long awns radiating round the valves might affiliate the present organisms to the genus *Bacteriastrum*, the two groups of forms differ very notably in other respects. Thus in the former there is as yet no proof that the frustules are arranged in series, while their general form is cylindrical or cylindroidal—one axis being much longer than the other—and the awns are never tortuous or dichotomous. But these characteristics are not wanting in the genus *Bacteriastrum*, hence the new series of forms, which unquestionably have certain affinities to *Chætoceros*, must be regarded as forming a transition to the tubulate *Rhizosoleniæ*.

The name that has been proposed for the genus has reference to the "broom"-like appearance of the frustules, and the following generic definition may be given:—Frustula cylindrica, libera (?); valvis convexis, setarum radiantium corona cinctis.

According to the character of the connecting zone and awns this genus may be divided into two sections, embracing—

A. Forms with simple smooth connecting zones and smooth awns.

B. Forms with complex annulate connecting zones and echinated awns.

Section A. *Connecting zones simple and smooth; awns smooth.*

Corethron criophilum, n. sp. (Plate XXI. fig. 14.)

Forma longe cylindrica, valvis producto-convexis, setis tenuissimis. In Antarctico ad glacies impervios.

This long and perfect little cylinder has a longitudinal axis, which bears to its diameter the ratio of 14 to 1. The awns are long and very delicate, smooth and radiating in the same direction at the two extremities. The two valves are extremely convex. This type occurs not unfrequently at the Antarctic ice barrier, and on floating fields of ice.

Corethron criophilum, n. sp., var. nov. (Plate XXI. figs. 12 and 15.)

Probably the frustules here shown only represent two varieties of the preceding species. Both differ, however, from the latter (1.) in having the longitudinal axis shorter and

[1] κόρηθρον, broom.

the diameter greater, and (2.) in possessing a cylindroidal rather than a cylindrical outline, while (3.) one has the valves exactly hemispherical, whereas in the other more protuberant form they are somewhat globular. Whether such distinctions have more than a varietal significance must at present remain somewhat doubtful, although the evidence would seem to indicate that a specific value may be ultimately assigned to them.

It may also be noted that the line bounding the upper valve in fig. 12 is undulating, while in fig. 15 it is straight, but provided with three well-marked involutions which are directed towards the centre of the frustule. The radiating awns in fig. 12 are also relatively larger and somewhat more elegant than in fig. 14.]

Corethron, sp. (Plate XV. fig. 7.)

The organism here represented, which has been figured from a preparation made on board the Challenger, is also manifestly a member of the present genus. In it the awns, which are not represented in full length in the figure, are very strong, long, and ribbed, and—a circumstance which is characteristic of the genus—they are never numerous, while their diameter is almost uniform throughout.

As this form has not been observed from its zonal aspect its real specific value must remain doubtful.

Section B. *Connecting zone complex, annulate; awns echinated.*

Corethron hispidum, n. sp. (Plate XXI. figs. 3 and 5.)

Forma cylindrica, annulata; valvis hemisphæricis spinulosis; setis costatis, echinatis. In mari Antarctico.

Although the frustules shown in the present figures undoubtedly belong to the same species, in only one are the details of structure represented. The connecting zone is composed of many hoops which are united together, and in this respect, through the genus *Lauderia* of Cleve, the genus *Corethron* approaches that of *Rhizosolenia*. The awns are strong, thorny, and costate, become gradually attenuated from their origin to their distal ends, where they are reduced to mere lines, and spring from the margin of the hemispherical valve, the surface of which is roughened by very minute thorns. The presence of these thorns has been employed in naming this interesting species.

Corethron murrayanum, n. sp. (Plate XXI. fig. 4.)

Forma cylindrica, annulata; valvis convexis, lævibus; setis costatis, echinatis. In mari Antarctico.

This somewhat large beautiful cylindrical organism—the longitudinal axis of which is equal to the diameter—has two convex valves, which have the form of the segment of a sphere. The cylindrical median zone is annulated, and a definite line of suture, as in

Podosira, is seen in the centre. The awns are ribbed, gradually attenuated, and bear sparsely disposed but well-defined thorns along their margins. The valves are perfectly smooth.

This exceedingly elegant Diatom was found in a preparation made on board the Challenger, and has been named in honour of Mr John Murray.

Corethron (?) sp. (?). (Plate XXI. fig. 6.)

The singular spherical organism here represented is provided with a raised zone, showing a double row of distinct round granules, and a corona of very fine echinated and slightly arcuate awns. Although it is by no means an easy matter to determine to what this strange form belongs, I am of opinion, from the fact that it has been found associated with other Corethral frustules, that it is a young form of a species of *Corethron*, the adult form being reached by the development of a connecting zone. The entire frustule would thus become cylindrical, and be terminated by two convex valves, which would be surrounded at their margin by a corona of granules and by circlets of awns.

Stephanopyxis, Ehrenb.

Greville[1] and Professor Walker Arnott, departing from the recognised laws of nomenclature, have desired to substitute the name *Cresswellia* for that of *Stephanopyxis* established by Ehrenberg. This substitution, however, has not been generally adopted, notwithstanding the claims that have been advanced in its favour, so that the old designation remains, the genus being defined as follows:[2]—"Frustules simple or united into short filaments, in front view orbicular or oblong, composed of two cellulose valves, each having a crown of teeth, spines or membrane; central portion obsolete; lateral view circular."

Stephanopyxis kittoniana, n. sp. (Plate IX. fig. 5.)

Frustulis globoso-cylindricis, lineariter punctulatis, et per apicum coronam inter se connexis. Ad insulas Philippinas.

This organism presents a series of four suborbicular frustules, which are united by means of a corona of capitulate processes, and are granulated or punctated in parallel lines running in the direction of the longitudinal axis of the series. Although some affinities are here presented to the *Cresswellia turgida* of Greville, for example, in general outline

[1] See Gregory, Diatoms of the Clyde, p. 64, pl. vi. fig. 109; Greville, *Micr. Journ.*, vol. vii. pp. 165, 166, pl. viii. figs. 14–16; *Trans. Roy. Soc. Edin.*, vol. xxi. p. 536; Ehrenberg, Die Infusionsthierchen, p. 165; *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1844, p. 264; Mikrogeologie, pl. xviii. fig. 4, pl. xix. 13, fig. 6.

[2] Pritchard, *op. cit.*, p. 826.

and in the form of the processes, it is to be noted that the latter is areolated instead of being delicately punctated, and instead of being globoso-cylindrical it is oblongo-cylindrical. The specific name of this Diatom, which was collected in the neighbourhood of the Philippines, has been given in honour of Mr Kitton, the well-known English micrographer.

Stephanopyxis rapax, n. sp. (Plate IX. fig. 9.)

Valvis convexis, lævi margine hinc grandiuscularum cellularum ordine cinctis, medio granulis rarioribus radiantibus ornatis; a cellularum corona decem aduncæ spinæ adsurgunt. In mari Antarctico.

This small discoid organism was obtained at Station 153,[1] lat. 65° 42′ S., long. 79° 49′ E., from a depth of 1675 fathoms, in a bottom of blue mud. It is terminated by a wide smooth border, within which a circle of very large cellules occurs. The disc is ornamented with delicate subradiating granules, which diminish slightly in size from the centre to the periphery. Between the central disc and the cellular corona ten strong claw-like structures arise—a characteristic which must be held as of specific importance.

Stephanopyxis turris (=*Cresswellia turris*, Grev.)

A specimen of this Diatom, which is unquestionably identical with the *Cresswellia turris* of Greville,[2] was obtained in the Arafura Sea. Although the species may be readily recognised when viewed in its zonal aspect, it is much more difficult to do so when seen from its valval side.

Stephanopyxis campana, n. sp. (Plate XIX. fig. 14.)

Oblonga, subcylindrica, valvis campanulatis, cellulosis, hemispherice terminatis et per paucos obtusos processus coronatis; cellulis confertis parvis, et marginem versus minuentibus. In mari Japonico.

This organism, which is figured in its zonal and most characteristic aspect, was observed among the Diatoms collected from the Sea of Japan. The valve is subcylindrical and oblong, and is twice as long as it is broad. The surface of junction is hemispherical and surmounted by a crown of truncated processes. The cavity of the valve is bell-shaped, and its external surface is densely cellular, the cellules diminishing as they approach the edge.

In many of the above characters this organism agrees with *Stephanopyxis apiculata*, Ehrenb.,[3] but the cellulation of the latter is described as "not crowded," and as being "arranged in longitudinal rows." But the most important character of *Stephanopyxis campana*, and one which, while it has not hitherto been recognised in any species, must

[1] This station was the nearest to the South Pole.

[2] *Trans. Roy. Soc. Edin.*, vol. xxi. p. 538, pl. xiv. fig. 109.

[3] Ehrenberg, Mikrogeologie, pl. xix. 13, fig. 6; Pritchard, *op. cit.*, p. 826.

nevertheless be viewed as of specific value, is the gradual diminution in size which the cellules undergo as they approach the margin.

Lauderia, Cleve.

Professor P. T. Cleve, in his Examination of Diatoms found on the Surface of the Sea of Java,[1] established this genus in honour of Mr Lauder, who has contributed so much to our knowledge of the genus *Chætoceros*, giving the following definition :—" Frustules cylindrical, side view orbicular; covered, at least near the margin, with numerous short hair-like processes or spines; front view annulated. Sculpture consists of very fine puncta."

The *Lauderiæ* are very well marked, and cannot readily be confounded with any other genus; it is, therefore, not easy to understand the grounds on which Professor H. L. Smith [2] failed to mention the genus in his Synopsis of the Families and Genera of Diatoms.

Lauderia annulata, Cleve. (Plate VIII. fig. 7.)

We have here represented an organism, found in a surface gathering made in the Antarctic Ocean, which is obviously identical with the *Lauderia annulata* of Cleve.[3] It need not therefore be further alluded to.

Lauderia elongata, n. sp. (Plate IX. fig. 4.)

Forma cylindrica, annulata, quatuor vicibus longior quam latior, per superficiem valde convexam terminata ; frustula in seriem per apicum coronam coherent. In mari Philippinarum.

This organism was found in a surface gathering made in the neighbourhood of the Philippine Islands. It differs from *Lauderia annulata*, Cleve, in the following noteworthy points : (1.) It is four times as long as broad, while in the latter the length is equal to the breadth ; (2.) its surfaces of junction are almost hemispherical, while in the latter they are hardly convex ; and (3.) it presents a line of junction around the middle of the annulated connecting zone—a feature which is not indicated in the figure of *Lauderia annulata* given by Cleve.

That these distinctions must be regarded as of specific importance is at once obvious.

Lauderia pumila, n. sp. (Plate IX. fig. 8.)

Frustula annulata cylindrica triplo longiora, punctulorum corona marginali seriatim disposita. Ad insulas Philippinas.

The four small cylindrical frustules here represented are annulate, and are in this respect similar to the species last described. In the present case, however, the contiguous

[1] *Bihang k. Svensk. Vet. Akad. Handl.*, Band I. No. 11, Stockholm, 1873.
[2] The Lens., vol. i., 1872.
[3] *Op. cit.*, p. 8, pl. i. fig. 7.

surfaces do not show the well-defined points which are so manifest in *Lauderia annulata*, Cleve, and *Lauderia elongata*, described above; on the contrary, a crown of marginal granules is alone represented. If then this organism be accepted as a *Lauderia* the definition of the genus must be extended to embrace both these conditions.

Lauderia (?) moseleyana, n. sp. (Plate XXIV. fig. 9.)

Forma cylindrica, annulata, parum longior quam latior; linea suturali excentrica; margine granulato. In mari Arafura.

This cylindrical Diatom from the Sea of Arafura is annulated and terminated by flat surfaces. The rings, however, though still of considerable diameter, are markedly narrower than in the preceding types. The individual frustules of a series are terminated at each extremity by a distinctly granulated line, and each at the same time presents a well-marked transverse line of suture which crosses the frustule nearer one end than the other. These lines are approximately at the same distance from the granulated terminal bands on both sides of each granulated area, so that two adjoining wider and two adjoining narrower zones succeed each other regularly.

The specific name has been given in honour of Professor Moseley of Oxford, who accompanied the Challenger Expedition as one of the Naturalists.

Rutilaria, Grev.

In 1863 Greville[1] established this genus for some rare and singular fossil organisms discovered in the deposits of Monterey and Barbados. Having only seen the valve of the frustule, the original definition was not, as might be expected, exact; but, after the discovery of other frustules adhering to one another, he amended this in 1866 in the following manner:[2]—"Frustules very compressed, cohering into a short filament; valves slightly elevated at the angles, with a central glistening nodule prolonged into two short linear, obtuse processes; the margin pectinate-ciliate."

The affinity of this genus with that of *Biddulphia*, which has also been recognised by Greville, presents no difficulty after a simple examination of its valval side, while the presence of a large central convolute nodule prevents it from being confounded with the genus *Nitzschia*. On the valval side of *Rutilaria* there may also be seen a well-defined elevation at each of the extremities. In *Biddulphia*, on the other hand, terminal processes or cornua occur, while generally the centre is convex and salient, and the adjoining frustules become united to one another by means of two long spines or setæ.

[1] *Quart. Journ. Micr. Sci.*, n. s., vol. iii. p. 227. The original definition ran as follows: "Frustules free, elongated, compressed, with a convolute or nodulose central nodule (no median line or terminal nodule), and minute radiate or decussato-punctate structure. Valve (linear, keeled?) with a longitudinal row of puncta."

[2] *Trans. Micr. Soc. Lond.*, n. s., vol. xiv. p. 124.

Owing to the great rarity of the *Rutilariæ*, the present forms have not been observed from the zonal aspects; and, with the exception of *Rutilaria epsilon*, Grev.[1]—whose convolute nodule recalls the shape of the Greek letter from which its specific name has been derived—it has been found impossible to determine the form of the nodule.

Hitherto no living specimens belonging to this very interesting genus have been recorded, and it is therefore of the highest importance that such specimens should have been procured during the Challenger Expedition. It is true, indeed, that Professor Cleve, of Upsala, records in his Memoir[2] on some New and Little Known Diatoms, Plate iv. fig. 57, a, b, under the name of *Rutilaria recens*, Cleve, two curious lanceolate forms which were brought home by the "Eugenie" Expedition[3] from the Galapagos Islands. These, however, have not the slightest trace of the convolute central nodule—a circumstance which should serve to exclude the organisms in question from the genus to which they have been ascribed by him—unless, perchance, it can be proved that one of the valves is normally devoid of such a nodule, as happens in *Cocconeis*. But this peculiarity has not hitherto been substantiated, and it seems an improbable one in the case of a genus whose frustules are disposed in series.

Of the specimens collected by the Challenger, one was obtained in a surface gathering, and so must have been in a condition of active vitality.

Rutilaria tulkii, n. sp. (Plate XVIII. fig. 11.)

Valvis elliptico-lanceolatis, apicibus productis, rotundatis et in partem elevatiorem exeuntibus; denticulis rariusculis marginalibus circumductis, et aliis medio irregulariter distributis; striis tenuissimis medio radiantibus, ceterum decussatis, nodulo centrali convoluto. Ad Samboangan ex insulis Philippinis.

This organism was found in a surface collection, in which hardly anything but small animals occurred. After washing these with distilled water, a preparation composed chiefly of spicula was obtained, but a more minute examination revealed the presence of the two small elegant frustules here figured, which were similar to one another, and arranged in a cruciform manner. I at first believed that this peculiar arrangement corresponded to the intersection of the axes of the figures, as occurs in some other genera, such as *Campylodiscus*, but after submitting this view to my friend, Mr Tulk, I became convinced that the frustules are enabled to have this disposition because of the peculiar form of the central nodules which form the real points of union between them.

A similar arrangement was also observed by Dr Gray, who had artificially caused two Rutilarian frustules to move from their normal parallel position.

Rutilaria tulkii possesses a small but elegant elliptico-lanceolate form, having its two

[1] *Quart. Journ. Micr. Sci.*, n. s., vol. iii. p. 228, pl. ix. fig. 1.

[2] *Kongl. Svenska Vetensk.-Akad. Handl.*, Band xviii. No. 5, Stockholm, 1881.

[3] The Expedition of the Royal Swedish Frigate "Eugenie" took place during the years 1851–53.

extremities notably prolonged, and terminated by a well-defined elevation in the form of a process. Around the margin there is a line of sparsely disposed granules or denticules, and the surface of the valve is delicately granulated in a radiating and decussate manner, a few more prominent granules being irregularly disseminated over the same area. The large central convolute nodule is so arranged as to render the exact determination of its form impracticable.

The specific name which I have adopted is in honour of my friend, Mr Tulk, who has aided me in many ways with my work.

Rutilaria edentula, n. sp. (Plate XVIII. fig. 14.)

Forma grandiuscula, lanceolata; apicibus longe porrectis, rotundatis in elevatiorem partem terminantibus; denticulis partem centralem cingentibus, hinc rariusculis, dein deficientibus; striis egerrime perspicuis, medio radiantibus; nodulo convoluto distinctiore. Ad insulas Philippinas.

This form was found among the Diatoms obtained in a sounding made at Station 211, in a depth of 2225 fathoms. It is much larger than the preceding, and is very different in outline and structural detail. It is lanceolate, but both extremities are much prolonged, and bear at their tips elevations which rise above the plane of the valve. The striation of the latter is extremely delicate in the central part, and can only be determined by the use of oblique light, and the exquisite homogeneous immersion objective of Zeiss. The marginal denticules are thicker than in *Rutilaria tulkii*, but they become more rare towards the extremities, and finally disappear. The central nodule is less prominent, and appears to be doubled up.

The specific name which has been applied is intended to recall the absence of marginal denticules at the extremities.

Melosira, Ag. (=*Gallionella*, Ehrenb.)

This genus was established by Agardh in 1824 for a series of frustules, having cylindrical, discoid, or globose outlines, and connected into cylindrical Conferva-like filaments, one or two lines passing round each frustule near the centre. Since the frustules are arranged in series, and assume somewhat the appearance of *Confervæ*, it is not surprising that, towards the end of the last century, O. F. Müller described, under the name of *Conferva armillaris*,[1] the *Melosira varians* of Agardh,[2] the siliceous nature of the walls not being then suspected.

The union of one frustule with another is either effected by means of convex surfaces or

[1] *Nov. Act. Holm.*, 1873, pl. iii. fig. 67. Rabenhorst places this frustule as a synonym under *Achnanthes longipes*, Ag. (Flora Europæa Algarum, p. 111, 1864).

[2] Ralfs, *Ann. and Mag.*, pl. ix. fig. 5; Rabenh., Süssw. Diat., pl. ii. fig. 4; Smith, Synop. Brit. Diat., vol. ii. p. 57, pl. li. fig. 332.

of plane spinous or denticulate surfaces, and on this account W. Smith, acting on the suggestion of Thwaites,[1] separated from the genus *Melosira* those forms which are connected in the manner last named, grouping them into the genus *Orthosira*. This scheme has, however, not been generally adopted, the character in question not being regarded as of generic significance, nor can it ever be defended unless the genus *Melosira* should ultimately become so rich in species that its separation into two parts should become necessary for the facilitating of systematic work.

Melosira sol, Ehrenb., var. nov. (Plate X. fig. 3, Plate XVII. fig. 13, and Plate XXI. fig. 7.)

Among the *Melosiræ* contained in the Challenger collection, the present forms, which were collected in the neighbourhood of Kerguelen Island, are of great elegance. The two complete frustules, which are united to one another by their valval sides (Plate XXI. fig. 7), although having very close affinities to *Melosira sol*, Ehrenb.,[2] cannot be regarded as identical with the latter. The description given by Pritchard[3] of *Melosira sol*, as determined by Ehrenberg, corresponds with the characters of the variety now in question with the exception of the fact that, in the latter, one additional feature has to be added —namely, the circumstance that between the radiating lines or plicæ, which run centripetally from the periphery and quickly disappear, more minute radial lines occur and also soon vanish. Although this is not clearly indicated on Plate XXI. fig. 7, owing to the insufficiency of the magnifying power employed, it is shown in Plate X. fig. 3 under a power of 800 diameters.

With the comparatively imperfect instruments used by Ehrenberg, it is not surprising that these fine lines escaped his observation.

Melosira costata, Grev., var. nov. (Plate XXIII. fig. 5.)

Among the pelagic organisms collected in the Bay of Yedo, the very elegant series of frustules represented in the present figure were not unfrequently met with. That these frustules belong to the genus *Melosira* cannot be questioned, and the presence of the longitudinally disposed costules, which are contiguous to the surface of junction of two adjoining valves, seems to point to their identity with *Melosira costata*, Grev. On comparing, however, Greville's figures[4] with the present one, the following differences may be noted:—(1.) The smooth areas around the different frustules of *Melosira costata* are almost equal, and in many more restricted than in the present form, where they are much larger and unequal; and (2.) in the typical Grevillean species these smooth areas

[1] Thwaites, *Ann. Nat. Hist.*, March 1848.

[2] = *Gallionella sol*, Ehrenberg, Mikrogeol., pl. xxxv. A. 22, fig. 12. This species rivals *Melosira arenaria*, Moore, in size, Ralfs, *Ann. Nat. Hist.*, vol. xii. pl. ix. fig. 4.

[3] Pritchard, *op. cit.*, p. 819.

[4] *Trans. Micr. Soc. Lond.*, n. s., vol. xiv. p. 77, pl. viii. figs. 3–6, 1866.

are oval, thereby indicating that the costules are of different lengths. Such distinctions, however, cannot be viewed as having more than a mere varietal significance.

Melosira westii, W. Sm. (Plate XXI. fig. 16.)

This frustule was observed on the coast of Australia, near Sydney, in a sounding made at a depth of 950 fathoms; but it is to be noted that the valves, instead of having "truncated apices," as described by Smith,[1] are depressed, a slight hemispherical projection occurring in the centre of the depressed area. These minor differences, however, are not essential, but they may be well seen on comparing the figures on the present plate representing the valval and zonal aspects.

We now pass to those species that are provided with a double furrow, and have their zonal sides divided into three parts.

Melosira hyalina, n. sp. (Plate XXI. fig. 1.)

Frustulis cylindraceis quadruplo longioribus, medio binis sulcis distinctis, apicibus hemisphericis; granulis imperspicuis; zona connectiva binatim junctis. In mari Pacifico meridionali.

Here each frustule is of cylindrical form, and is four times as long as it is broad. Two furrows occur towards the middle, and are placed at a distance from one another equal to the length of the transverse axis of the frustule. In the figure two frustules are seen to be united to one another by a common belt, and both are terminated by hemispherical surfaces. It is noteworthy, however, that the surface of junction between the adjoining frustules is flat. This curious circumstance is of little importance, and may probably be explained in the following manner. In the final stages of increase in size, the extremities are prevented from dilating by the resistance which is offered by the common belt which has already ceased to lengthen, so that lateral expansion occurs, and a flat septum is the result.

The prolonged cylindrical form of the frustule and the prominent hemispherical extremities are, however, of specific importance.

This interesting form was collected near the Pacific coast of South America in a depth of 2225 fathoms.

Melosira thaitiensis, n. sp. (Plate XXI. fig. 2.)

Cylindracea, triplo longior quam latior; binis sulcis medio signata; apicibus convexo-complanatis, exterius granulatis; ordine quadrato punctulatis. In portu Thaiti.

This Diatom, from the port of Tahiti, is composed of cylindrical frustules, which are three times as long as wide, and terminate in convex depressed extremities or surfaces of

[1] Synopsis of British Diatomaceæ, vol. ii. p. 59, pl. lii. fig. 333.

junction, which are crowned by denticules. Each is provided with a double furrow near the centre, and the partitions are densely granulated in a quadrate manner.

This new species has been named from the locality in which it was first observed.

Melosira glomus, n. sp. (Plate XXI. fig. 10.)

Frustulis cylindraceo-suborbicularibus, dense quadrato ordine punctulatis, medio zona lævi cinctis. Ad portum Thaiti.

The spheroidal frustules which compose this Tahitian Diatom present very many granulations save in the smooth linear zone which surrounds each in the middle region. The entire series is irregular on account of the different conditions of development of the component parts, and the valves also vary from the subhemispherical to the depressed convex form. But for the condition of the median band this form would agree with the *Melosira labuensis* of Cleve; but its true specific value cannot, in view of the characters quoted, be called in question.

The specific name has been given from its resemblance to balls of coarse thread.

Plate XXIII. fig. 4, represents a variety of *Melosira glomus* from the port of Tahiti; it may be named *Melosira glomus*, n. sp., var. *major* nov.; while Plate XXI. fig. 11, is a doubtful species of the same genus collected in the Sea of Japan.

Thalassiosira, Cleve.

This genus was established by Professor Cleve of Upsala, in his paper On Diatoms from the Arctic Sea,[1] and was characterised by him in the following manner:—"Side view circular, with a row of submarginal spines; sculpture very minutely cellular, cellules arranged in radiating and curved lines, crossing each other. Front view quadrangular, with truncate angles, connecting membrane broadly linear, without any distinct sculpture. Frustules, in the living state, connected by means of a central fine thread of mucus into long filaments."

From specimens of remarkable purity obtained from the Arctic Sea, and more especially from Davis Straits, Cleve established the species *Thalassiosira nordenskiöldii*.[2] This Diatom occurs in these regions in such enormous quantities as to colour the sea for many miles, but I have not observed it in the collections made by the Challenger in the Antarctic Ocean among the South Polar icebergs. It is, however, of the greatest importance to note that I have recently found numerous specimens of *Thalassiosira* along with many other Diatoms in the alimentary canals of two Echini which were procured at a depth of 1340 fathoms in lat. 41° 15′ N., long. 65° 45′ W. These frustules constituted the food of

[1] *Bihang k. Svensk. Vet. Akad. Handl.*, Band i., No. 13, p. 6, pl. i. figs. 1*a*, 1*b*, 1*c*, 1*d*, Stockholm, 1873.

[2] *Op. cit.*, p. 7.

the animals in question, and so must have been growing in their immediate vicinity at a depth at which, notwithstanding the great distance from the poles, the temperature of the water approaches zero.

Thalassiosira nordenskiöldii, Cleve, var. nov. (Plate XXX. fig. 4.)

This figure represents a Diatom with a characteristic corona of submarginal spines which was found in the vicinity of the Bermudas; while fig. 4 *bis* of the same Plate is a reproduction from the Synopsis des Diatomées de Belgique of Dr van Heurck[1] of the *Thalassiosira nordenskiöldii* of Cleve, the former being magnified 850 diameters, and the latter 600 diameters. In the frustule, now for the first time recorded, the radial striation is so minute that it is difficult to observe even in dried specimens, while the number of prickles or submarginal spines is much greater than in the Arctic form. Hence, although the two might be regarded as distinct species, I prefer to look upon the deep-sea form as a variety of the surface form of Cleve until such time as the former is procured in a living condition, and its history more accurately known.

Isthmia, Ag.

Isthmia enervis, Ehrenb., var. *japonica*, nov. (Plate XXV. fig. 5.)

The only form belonging to this genus which has to be recorded is one from the Sea of Japan, which presented an evident analogy to *Isthmia enervis*, Ehrenb.,[2] yet differed from it in several respects. Thus (1.) the profile of the frustule on the zonal side is simply trapezoidal in Ehrenberg's species, while in the Japanese form the two oblique terminal lines are more or less undulating—a distinction upon which much weight cannot be placed. (2.) At the margins of the median band, and adjoining the two sutural lines, a row of larger granules occurs in both cases, as in *Biddulphia;* but the band itself is ornamented, in *Isthmia enervis*, by small round quincuncially-arranged granules, while in the present case the granules are somewhat oval, and are not arranged in a quincunx manner. (3.) It may also be observed that in the Japanese Diatom the strong granules at the two extremities are somewhat different from one another, being on the more obtuse side subquadrate and of larger size than on the other side, where they are subrotund.

Notwithstanding these differences, the frustule from the Sea of Japan must be regarded as possessing merely a varietal importance, and the distinctive name that has been applied has reference to the locality in which it has been first collected.

[1] Pl. lxxxiii. fig. 9.

[2] Ehrenb., Inf., p. 209, pl. xvi. fig. 6; Kütz., Bacill., pl. xix. fig. 4; Smith, Synop. Brit. Diat., vol. ii. p. 52, pl. xlviii.; Jan. et Rabenh., Hondur., p. 9, pl. iv. fig. 13; Hohenack., Alg. Mar., N. 454; Ralfs, Ann., vol. xii. pl. viii. fig. 1. Compare also *Isthmia obliquata* var. *tenuior*, Ag. Conspec., p. 55, and *Conferva obliquata*, Eng. Bot., tab., 1869.

Eucampia, Ehrenb.

This genus is defined by Pritchard in his History of the Infusoria (p. 937) as follows:—"Frustules hyaline, imperfectly siliceous, cuneate, without terminal puncta, united in a jointed spiral filament." With regard to this definition, it may be noted that although, with the relatively imperfect microscopes used by Ehrenberg and W. Smith, by means of which the minute sculpturing could not be detected, it was admissible to speak of the frustules as *hyaline*, it is now possible to detect minute rows of points, so that that term can no longer be made use of.

Akin to the genus *Eucampia*, Professor Cleve of Upsala, in his paper entitled Examination of Diatoms found on the Surface of the Sea of Java,[1] instituted another genus which he named *Mölleria*, in honour of the well-known mounter of Diatoms, and gave a definition which agrees with that of *Eucampia*, except that, in *Mölleria*, the extremities of the valves are produced into long processes, and the connecting membrane is ornamented with numerous costæ (rudiments of diaphragms?). That the presence of long processes is an insufficient character upon which to establish a genus is manifest, and in his Synopsis of the British Diatomaceæ, W. Smith,[2] in representing a superb specimen of *Eucampia zodiacus*, Ehrenb., indicates a slight puncturing on the valve, and traces of several costæ on the connecting zone. Hence the genus *Mölleria* cannot be accepted on the grounds quoted by Cleve. But in *Mölleria cornuta*, Cleve, there exists a central nodule which—as I observed in the case of a valve found in the original collection from the Sea of Java, which was kindly placed at my disposal by Professor Cleve—is ornamented by minute radiating puncta. Hence it only remained to be shown that, in *Eucampia*, no central nodule occurred, in which case the genus *Mölleria* could be reserved for those forms of *Eucampia* possessing such a structure, and defined as indicated on page 98.

Among the Challenger collections, series of cuneate frustules, without the terminal point or appendage, and having all the peculiarities required by the definition of *Eucampia*, Ehrenb.—except that, instead of being imperfectly siliceous or hyaline, they were furnished with large granules—have been seen on several occasions. Hence the characters of *Eucampia*, as established by Ehrenberg, may be emended thus:—Frustula cuneata in duas inæquales extremitates abrupte desinentia et in seriem spiralem conjuncta.

Eucampia balaustium, n. sp. (Plate XVIII. fig. 5.)

Valvis ellipticis convexis superne in duos inæquales processus truncatos desinentibus et medio inflatis; granulis grandiusculis nullo certo ordine stipatis. In mari Antarctico.

Each frustule here consists of two elliptical valves, which terminate above in two unequal imperfect processes, between which a slight protuberance exists. The valves,

[1] *Bihang k. Svensk. Vet. Akad. Handl.*, Bd. I. No. 11, p. 7.

[2] Smith, Synop. Brit. Diat., vol. ii. p. 25, pl. xxxv. fig. 299., and Suppl., pl. lx. fig. 299.

when seen in the zonal aspect, are symmetrical in themselves, but each is unsymmetrical with reference to the transverse axis. Their surface is ornamented with large irregularly disposed granules. No distinct connecting zone is seen, the two adjoining valves being immediately united. In some frustules a smooth belt may be observed between the two valves.

The specific name has reference to the form of the frustule.

Eucampia balaustium, n. sp., var. *minor*, nov. (Plate XVIII. fig. 6.)

We have here represented a form which must be regarded as a mere variety of the preceding type, differing from it in its smaller size, and in having the extremities somewhat blunted.

It is important to note that, as may be observed in this figure, the last valve in the series differs from the others, having the two extremities less prominent and of equal length. In this circumstance *Eucampia* resembles *Bacteriastrum*, *Chætoceros*, and probably also *Hemiaulus*.

Mölleria (Cleve), Cstr.

As above referred to (see *Eucampia*, p. 97), this genus, instituted by Cleve in honour of M. Möller, of Wedel, Holstein, does not differ essentially from *Eucampia*, except by the presence of a nodule in the centre of the valve, and by possessing two unequal terminal processes. Hence the genus may be defined as follows:—Frustula cuneata in spiralem seriem conjuncta; valvis ovalibus centrali nodulo instructis, et in duos inæquales processus desinentibus; zona connectens plerumque crebre costata vel plicata.

Mölleria cornuta, Cleve. (Plate XXV. fig. 8.)

We have here shown a small specimen of *Mölleria cornuta*, Cleve,[1] which has hitherto been unique in its kind. Two frustules are seen in series, and the shorter of the two has been checked in the act of fission, so that two new valves, in process of formation, may be observed through the belt. Similar observations have already been made in the case of *Biddulphia*, and in other types possessing two symmetrical valves.

Mölleria antarctica, n. sp. (Plate XVIII. fig. 8.)

Forma cuneata grandiuscula, valvis ellipticis vix perspicue punctulatis et nodulo centrali instructis; cingulo costulato vel plicato, bipartito; processibus terminalibus parum productis. In mari Antarctico.

[1] Cleve, Examination of Diatoms found on the surface of the Sea of Java, *Bihang k. Svensk. Vet. Akad. Handl.*, Bd. I. No. 11, p. 7, Stockholm, 1873.

This Antarctic Diatom differs from the *Mölleria cornuta* of Cleve in the following respects:—(1.) The greater size of the frustules; (2.) the greater shortness of the terminal processes; (3.) the inferior degree of development of the connecting zone; and (4.) the bipartite condition of the connecting zone; the costæ, moreover, of the two hoops of adjoining valves often diverge more or less—a peculiarity which has not been observed in Cleve's species. Although taken singly, these differences probably are not of very great importance; it cannot be doubted that the combination of all of them is sufficient to warrant the establishment of this new species.

Hemiaulus, Ehrenb.

Seeing that the frustules of this genus are provided with two processes terminated by a thorn or claw, we are led to conjecture, in opposition to the assertion made by Pritchard,[1] that the frustules exist in a concatenate or seriate form, since the spine can only be interpreted as a connecting organ. This conjecture I have been able to verify more than once by observing two or more frustules linked together, and in such a manner that their terminal spines constantly alternate with one another. Thus of the two spines of one valve, one is superposed to the corresponding spine of the adjoining frustule, while the other is covered by its corresponding spine. This peculiar method of union may also be studied in the genus *Chætoceros*, but its signification is by no means easy to understand. The concatenation of *Hemiaulus* was observed, and accurately described, by Heiberg, in his work entitled Conspectus criticus Diatomacearum Danicarum, plate i. a.

In *Hemiaulus*, as in *Chætoceros* and *Cocconeis*, the terminal valve differs somewhat from the others—a circumstance which must be carefully borne in mind in order not to multiply species unduly. The overlooking of this fact explains why, in Pritchard's History of the Infusoria, the different condition of the processes, as elongated in one valve and truncated in the other, is given as a specific character of *Hemiaulus antarcticus*,[2] Ehrenb. But the processes of the terminal valve are truncated in all the species, since the spine becomes superfluous where union with another frustule does not take place.

Hemiaulus, sp. ? (Plate XXI. figs. 9 and 13.)

The two valves of *Hemiaulus* here figured must be regarded as terminal, but their specific determination must for the present remain doubtful. The only circumstance—apart from the more crowded condition of the granules—which would seem to indicate that the valve represented in fig. 13 belongs to a distinct species from that shown in fig. 9, is the existence of a well-defined granule, surmounting its two obtuse terminal processes, instead of the simple spine or process which is peculiar to the latter.

[1] Pritchard, *op. cit.*, p. 851.

[2] Ehrenberg, Mikrogeologie, pl. xxxv. A 22, fig. 15; Pritchard, *op. cit.*, pl. xi. fig. 54.

Hemiaulus glacialis, n. sp. (Plate XXV. fig. 4.)

Processus laterales elongati truncati, mucronati; intermedia frustuli inflatione utrinque septata; granulis perspicuis stipatis. In mari Antarctico.

This valve, which is perfect, is furnished with two long parallel processes, which are truncated at the ends, and upon each of which a well-defined claw-shaped terminal spine projects from the internal part. Between the long processes, and in the centre of the valve, a slight protuberance or swelling occurs, indicating, when seen in profile, that the plane of the valve must be crossed by two septa. This frustule, which has not been hitherto figured, has been named *glacialis*, on account of its Antarctic habitat.

Cerataulus, Ehrenb.

Professor H. L. Smith[1] has united the genera *Cerataulus*, *Odontella*, *Zygoceros*, and others, under the single genus *Biddulphia*—a circumstance which has rendered the classification much more intricate, and which therefore should not be adopted, notwithstanding the intimate relation that exists between all these organisms. The oval shape of the valves, the alternation of the two sublateral processes, and the strong horn-like spines, in the case of *Cerataulus*, compared with the disposition of the frustules in zigzag chains, or their adhesion to each other by alternate angles, the elongated and often septate character of the valves, and the presence of subterminal processes in *Biddulphia*, must be regarded as essential distinctions between the two genera. This view has also been adopted by other naturalists, among whom Dr Eulenstein may be mentioned. This observer, in issuing the first hundred of his typical preparations, gave, under Nos. 9 and 10, *Cerataulus lævis*, Ehrenb.,[2] and *Cerataulus turgidus*, Ehrenb.,[3] and under No. 11 *Biddulphia pulchella*, Gray,[4] recognising, as an essential characteristic of *Cerataulus*, the possession of strong

[1] Pritchard, *op. cit.*, p. 847. *The Lens*, vol. i. 1872, p. 89.

[2] = *Gallionella*, sp.? Bailey, 1842; *Sil. Journ.*, vol. xlii. pl. ii. fig. 8.
Biddulphia lævis; Pritchard, *op. cit.*, p. 847, pl. vi. fig. 7; Roper, *Micr. Journ.*, vol. vii. p. 18, pl. ii. figs. 24–26.
Odontella polymorpha, Kütz., Bac., 1844, pl. xxix. fig. 90; Kütz., Spec. Alg., 1849, p. 136.
Isthmia polymorpha, Montagne } Quoted in Kütz., Spec. Alg., 1849, p. 136.
Melosira thermalis, Meneghini }

[3] Ehrenberg., *Monatsber d. k. Akad. d. Wiss. Berlin*, 1843, p. 270; Bailey, 1850, Micr. Obs., pl. ii. figs. 26 and 27.
= *Biddulphia turgida*, Smith, Synop. Brit. Diat., vol. ii. p. 50, pl. lxii. fig. 384; Roper, *Micr. Journ.*, vol. vii., p. 17, pl. ii. fig. 23.

[4] Gray, Nat. Arr. of Brit. Plants, vol. i. p. 294; Ralfs, *Ann. Nat. Hist.*, 1843, pl. viii. fig. 3.
= *Conferva biddulphiana*, Eng. Bot., 1807, vol. xxv. tab., 1762; Dillwyn, Brit. Conf., 1809, p. 52.
Diatoma biddulphianum, Ag. Syst. Alg., 1824, p. 5, and Conspec. Crit. Diat., 1830, p. 54. Hooker's Brit. Flor., 1833, p. 404; Harvey, Man., 1841, p. 201.
Biddulphia trilocularis, Kütz., Bac., 1844, pl. xix. fig. 89, and Spec. Alg., 1849, p. 137.
Biddulphia quinquelocularis, Kütz., Bac., 1844, pl. xix. fig. 1, and Spec. Alg., 1849, p. 137.
Biddulphia septemlocularis, Kütz., Bac., 1844, pl. xix. fig. 2, and Spec. Alg., 1849, p. 138.
Biddulphia australis, Mont., Pl. Cel. de Cuba, 1845, p. 5.

horn-like processes, which are not situated on the protuberances between the two processes, but alternate with them.

Cerataulus turgidus, Ehrenb., var. *polyceros*, nov. (Plate XXVI. figs. 6 and 8.)

The organisms here figured belong to the genus now before us, although the valve is of considerable size, and is distinguished by the presence of some well-defined irregularly scattered granules. That both forms, which were collected in the same locality—the Sea of Japan—represent the same species is unquestionable.

The general aspect and sigmoid curve of the frustule and connecting zone point to affinities with the *Cerataulus turgidus* of Ehrenberg. On comparing, however, our two figures with the *Cerataulus turgidus* of the Typenplatten of Möller, and with the different specimens which we find in the typical preparations of Eulenstein, they agree in all respects, except that Möller's specimen is provided with a remarkable crown of thorns, along with very small irregularly scattered valval thorns, while in the frustules of Eulenstein's preparation only the very minute thorns occur — differences that are of little moment. In the case of the Challenger forms, on the other hand, the minute thorns are entirely absent; and, instead of a strong long point or cornu alternating with the two short processes, there is present a group of strong, short obtuse cornua. These marks of distinction have been looked upon as sufficient to justify the establishment of a new variety.

Biddulphia, Gray.[1]

Although, as above stated, I cannot adopt the view of Professor Smith, according to which he would unite the genus *Cerataulus*, Ehrenb., to that of *Biddulphia*, I am of opinion that the union of the genera *Zygoceros*, Ehrenb.,[2] *Odontella*, Ag.,[3] *Porpeia*, Bailey,[4] and *Amphitetras*, Ehrenb.,[5] to that genus as advocated by him is well founded. Thus the only difference of any importance between *Zygoceros* and *Biddulphia* is the circumstance that the frustules of the former are isolated. A *Biddulphia*, however, may also be found solitary, not only as a result of having been casually detached from a series, but because its mode of reproduction supposes that, at some time, the frustule should occur free. Again, only the absence of spines on the margins of the valve distinguishes *Odontella*

[1] Gray, Nat. Arr. of Brit. Plants.

[2] Compare *Zygocerus mobilensis*, Bail., Smithson. Contrib., 1859; *Zygoceros rhombus*, Ehrenb., Kreideth., p. 80, N. 61, pl. iv. fig. 11; Kütz., Bac., pl. xviii. fig. 9; *Zygoceros surirella*, Ehrenb., Kreideth., *loc. cit.*, fig. 12, Kütz., *loc. cit.*, fig. 12; Roper, *Micr. Journ.*, vol. vii. pl. vi. figs. 11 and 12.

[3] Ag. Consp., 56, Kütz., Bacill., pl. xviii. fig. 89, pl. xxix. figs. 88 and 90; Wigand in Hedwigia, vol. ii. p. 45, pl. vii. fig. 21, Montagne, Syll., p. 473.

[4] Bailey, MS. Pritchard, *op. cit.*, p. 850, pl. vi. fig. 6.

[5] Ehrenb., Kreideth., p. 62, N. 22; Ralfs, *Ann. and Mag.*, vol. xii. pl. viii. fig. 5; Smith, Synop. Brit. Diat., vol. ii. p. 47, pl. xliv. fig. 318; Jan. et Rabenh., Hondur., p. 4, pl. i. fig. 3; Heiberg, Conspec., p. 42, &c.

from *Biddulphia;* while, like *Zygoceros, Porpeia* differs from it merely by living in an isolated condition. In *Amphitetras* the valves are subquadrate, and provided with four pseudo-openings at the angles, while in *Biddulphiä* there are only two. Yet the structure of both of the latter types is the same, while the number of pseudo-openings depends on the form of the valve—there being one at each angle; thus some triangular forms, or forms with four or more angles, each provided with a pseudo-opening, occur, and have hitherto been named *Triceratium,* but these must in future be enrolled among the *Biddulphiæ. Amphitetras* agrees with *Biddulphia* in its zigzag appearance, the union between its frustules being effected by means of an isthmus or small angular cushion; and, in its structure, it agrees with the latter so far as to possess a pseudo-opening at each extremity. Moreover, *Amphitetras antediluviana,* Ehrenb.,[1] is frequently found associated with the *Biddulphia pulchella* of Gray, which is but another proof of the affinity of the two types.

Biddulphia pulchella, Gray, var. *major,* nov. (Plate XXIII. fig. 6.)

We have here represented a very large valve divided by six transverse lines or septa, the characters of which exactly agree with the definition of the *Biddulphia pulchella* of Gray, except that the strong thorns, which are constantly found in groups of two or three in the latter, are absent in the former. For this reason, the present form has been referred to as a variety, a view which is, in part, substantiated by its unusually large size. It was collected in the Caroline Archipelago.

Biddulphia reticulata, Roper, var. *inermis,* nov. (Plate XXVI. fig. 9.)

Another beautiful form of this genus is here shown. It possesses reticulated parietes, and two opposite capital processes, towards the extremities of which the network disappears. Between the two latero-terminal processes the end of the frustule is slightly inflated or convex. In these respects it resembles *Biddulphia reticulata,* Roper,[2] but it may be distinguished from the latter by the absence of superficial puncta.

It may be observed that in the present figure the two frustules are united together by means of two hoops or belts, which embrace each other, and each of which shows a different internal structure from that of the valve. This appearance enables us to understand the transitory nature of the belt in some forms, as has been already pointed out by Dr Wallich, who observed that it did not form an integral part of the frustule, but was joined to it by means of several distinct oblong cellules.

This elegant organism was collected at the Philippine Islands.

[1] Pritchard, *op. cit.,* pl. xi. figs. 21 and 22.

[2] *Trans. Micr. Soc. Lond.,* vol. vii. p. 14, pl. ii. figs. 13–15.

Biddulphia parallela, n. sp. (?) (Plate XXIII. fig. 10; Plate XXVI. fig. 7.)

To the genus *Biddulphia*, and probably to the section *Amphitetras*, belong the forms here represented. In both cases one valve has a shorter diameter than the other—an appearance that may be explained by the fact that the two valves are not exactly in the same plane. The system of granulation, however, and the form of the processes, each of which terminates in a pseudo-opening, shows that the two specimens belong to the same species.

These interesting types were collected in the Sea of Japan.

Biddulphia pellucida, n. sp. (Plate XXVI. fig. 5.)

Valvis late ellipticis, inconspicue punctulatis; apicibus rotundatis parum productis; valvis ad centrum inflatis. Ad insulas Philippinas.

This organism, which is from the neighbourhood of the Philippine Islands, belongs to the Odontelloid section. Its sculpturing is so delicate that punctations can only be observed with great difficulty under oblique illumination, and with the best microscopes, so that it could only have been shown in the figure by the use of a much greater magnifying power than has been there employed. The encapsuling of the two valves by means of two hoops or belts, which extend over one another, is well seen, but no third protective hoop accessory to the process of deduplication, and possessing a distinct structure, is here found. The angles of this form are sharply prominent and rounded, while the centre of the valve is very protuberant.

The specific name, which has been applied to this new species, has reference to the great delicacy of its ornamentation.

Biddulphia pumila, n. sp. (Plate XXIII. fig. 12.)

E minimis; valvis hirsutis-convexis immediate connexis, quadrato ordine punctulatis; angulis productis conicis. E mari Japonico.

The series of frustules here represented are akin to *Biddulphia aurita* (Lyngb.)[1] Breb., but their extraordinary minuteness and the difference in the outline of the valval side, as well as the fact that the two valves join each other directly without a cylindrical intermediate zone, prevents me from uniting the two types. Moreover, in the present

[1] Brebessin, Cons. sur les Diat., 1838, p. 12; Ralfs, *Ann. Nat. Hist.*, vol. xii., 1843, pl. viii. fig. 4; Smith, Synop. Brit. Diat., vol. ii. pl. xlv. fig. 319; Microg. Dict., 1856, pl. xiv. fig. 10; Roper, *Micr. Journ.*, vol. vii. p. 10; Heiberg, Conspec., p. 40; Jan. et Rabenh., Hondur., p. 5, pl. iii. fig. 14; =(1.) *Denticella aurita*, Ehrenb., Mikrogeol., 1854, pl. xxxv. A 23, fig. 7; (2.) *Denticella gracilis*, Ehrenb., *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1840, p. 207; (3.) *Diatoma auritum*, Lyngb., Tent. Hydro. Dan., 1819; Hooker, Brit. Flor., 1833, p. 404; (4.) *Odontella aurita*, Ag., Consp. Crit. Diat., 1830, p. 56; Smith, Eng. Bot., t. 2842, fig. 2; Harv., Man., 1841, p. 201; Kütz., Bac., 1844, pl. xxix. fig. 88; Kütz., Spec. Alg., 1849, p. 136.

case, none of the long thorns characteristic of *Biddulphia aurita* occur. The valves are hirsute, convex, and ornamented with quadrately disposed punctations, while the angles are of conical form.

The series, which is formed by the direct union of the frustules, was collected in the Sea of Japan.

Biddulphia japonica, n. sp. (Plate XXIII. fig. 14.)

Forma parva; valvis convexis, areolato-punctulatis; apicibus productis acutiusculis, ad basim inflatis; cingulo cylindrico punctulato. In mari Japonico.

This frustule, from the Sea of Japan, is not much larger than those of *Biddulphia pumila*, n. sp., from which, however, it is at once distinguishable by its areolate ornamentation, and by the fact that the angles which are equally prominent are not simply conical, but present a protuberance near the base. The cylindrical cingulum is punctated.

Biddulphia, sp. (?) (Plate XXVI. fig. 1.)

The valve here shown is from the Arafura Sea. It possesses an elliptico-lanceolate form, with rounded, somewhat mammiform vertices, while the surface has distinct granules which radiate from a very excentric point. Near the extremities there are two small pseudo-openings. Although this valve cannot be identified with any species hitherto recorded, it does not afford the means of fully determining the characters of the new species which it represents.

Biddulphia, sp. (?) (Plate XXIII. fig. 13.)

This organism, like the one last mentioned, cannot be identified with any known species, and is insufficient to enable a complete conception of the new species, which it typifies, to be obtained. It is of elliptical form, and its punctations radiate from the centre, at which a small group of more salient granules or denticules occur.

Biddulphia weissflogii, Grun. (Plate XXVI. fig. 2.)

Forma subquadrata, decussatim punctulata; apicibus parum productis linea axiali vix perspicua unitis; valvis ellipticis, ad centrum subinflatis, duplici brevi cornu excentrico ad apices instructis.

This perfect frustule is adorned with very minute granules, disposed in a quincuncial manner. Its extremities are slightly prolonged and rounded, and, when seen from the zonal aspect, each presents two short strong conical and slightly curved points, which are quite characteristic of the species.

In Plate c. figs. 1 and 2, of the Synopsis des Diatomées de Belgique, by Dr H. van Heurck, there is represented a frustule which is identical in its principal characteristics with that brought home by the Challenger which is now being considered. It has been

named *Biddulphia weissflogii* by Grunow, who gives South Africa as its locality. The Challenger Diatom must accordingly be designated by the same specific name.

Biddulphia (Amphitetras) ornata, Shadb., var. *hirsuta,* nov. (Plate XXIII. fig. 9.)

The frustule here shown recalls the *Amphitetras ornata* of Shadbolt,[1] as it agrees with the latter in its quadrate form, its concave sides, the evident granulation, and the reticulate linear veining. On comparing the present form, however, with the specimen of *Amphitetras ornata* of the Typenplatten of Möller, it may be observed to differ in the somewhat greater concavity of the walls and the consequent prolongation of the extremities, and also in the presence of a corona of spines or puncta. Moreover, the precision with which the details of sculpture are represented in the Typenplatten show that the valve is not flat, a feature which could not be seen in the present case. Notwithstanding these differences, the Challenger frustule, which was collected in the Sea of Japan, can only be viewed as a variety of Shadboldt's species, which, however, should receive the generic designation *Biddulphia,* instead of *Amphitetras.*

Biddulphia (?) sp. (?) (Plate XIX. fig. 1; Plate XXX. fig. 9.)

A very singular Diatomaceous frustule is shown on Plate XIX. fig. 1, and again under a somewhat higher magnifying power on Plate XXX. fig. 9. The two figures have been given because of the omission of a character of great importance in the former, namely, the occurrence of a small area, ornamented with small crowded granules, at each of the rounded angles of the slightly concave side, a peculiarity which occurs in *Triceratium arcticum,* Bright. As only one specimen of this form has been observed, it has been found impossible accurately to determine to which genus it belongs. The slight prominence of the two adjacent extremities of the concave side seems to point to its being a *Biddulphia,* but the marked want of symmetry in the two valves opposes this view, although this last circumstance may point to the fact that it may have formed part of a seriate Diatom, of which it may have represented the terminal frustule, thus recalling the irregular appearances that are found in many forms of *Chætoceros* and *Bacteriastrum.* The characters of the frustule are the following:—Zonal profile of frustule subquadrate, with one side slightly concave; angles rounded; two transverse diaphragms or septa dividing the frustule into three approximately equal parts; surface of parietes covered with thinly disposed subparallel rows of oval granules; granulation becoming abruptly crowded and more delicate near the angles on the concave side. Locality: Sea of Japan.

The frustule was found in a preparation generously placed at my disposal by Dr James Rae, R.N.

[1] *Trans. Micr. Soc. Lond.,* vol. ii. p. 16, pl. i. fig. 10.

On Plate XXVI. fig. 10, there may be seen *Biddulphia tuomeyi*, Bail.,[1] and on Plate XXX. fig. 6, a variety of this—*Biddulphia tuomeyi*, Bail., var. *pacifica*, nov., from the Pacific Ocean.

Biddulphia roperiana, Grev.,[2] is represented on Plate XXVI. fig. 4.

Triceratium, Ehrenb.

Soon after Ehrenberg established the genus *Triceratium* among the *anguliferous* Diatoms, frustules were found which exactly corresponded to its essential characters, but which had valves with four or five angles, and these frustules were admitted into the genus as exceptional forms—*Triceratium* being defined as possessing "valves rarely with four or five angles."[3] Later on, frustules with six, seven, and even twelve angles had to be enrolled, as, for example, the *Triceratium eulensteinii* of Grunow (see A. Schmidt, Atlas, Plate lxxv. fig. 6). Although this last species is probably a real *Stictodiscus*, it can hardly be doubted that, if Ehrenberg had foreseen the extension of his genus to embrace polyangulated frustules, he would have chosen the name *Polyceratium*. The following is the definition of the genus *Triceratium* as given by Pritchard :—"Frustules cellular, free, simple, in lateral view triangular (rarely with four or five angles)."

More than 200 species have been ascribed to this genus, about 150 being figured in the Microscopical Journal alone. It is to be remarked, however, that many of these so-called "species" have no real claim to be regarded as true specific types, and several forms which have been observed amongst the Challenger material have been relegated to polygonal types of *Stictodiscus*, although they might at one time have been placed in the present genus.

Triceratium pulvillus, n. sp. (Plate VI. fig. 8.)

Valvis quadratis, areolatis vel cellulatis; laterales lineæ late concavæ; apices acuto-rotundati; areolæ æquales, hexagonales; processu terminali nullo. Ad mare Philippinarum.

This quadrate frustule from the Philippine Sea possesses greatly hollowed-out sides and acute rounded extremities. The whole surface is occupied by equal areolæ or hexagonal cellules, there being no trace of any process on the extremities.

Triceratium thaitiense, n. sp. (Plate XIII. fig. 14.)

Hexagonum, lateribus concavis, apicibus rotundatis; valva punctulis rariusculis signata. In portu Thaiti.

This hexagonal form was observed in a collection made with a tow-net, at a small depth in the port of Tahiti. It is provided with concave sides and rounded extremities, but

[1] = *Zygoceros tuomeyi*, Bail., *Amer. Journ.*, vol. xvi. pl. iii. figs. 3–9; Pritchard, *op. cit.*, p. 848, pl. vi. fig. 10.

[2] *Micr. Journ.*, vol. vii. pl. viii. figs. 11–13.

[3] Pritchard, *op. cit.*, p. 853.

has no processes of any kind from the valve, which is ornamented with small, ill-defined, thinly placed, almost punctiform granules, which decrease towards the extremities.

Triceratium ferox, n. sp. (Plate VI. fig. 4.)

Triangularis; apicibus cuneato-rotundatis, prominulis; lateribus rectis; dentibus nonnullis marginalibus erectis; valva cellulis vel areolis grandiusculis hexagonis. In mari Japonico.

This frustule is figured both from its zonal and valval aspects. It is small, triangular, and provided with large hexagonal areolæ. Its sides are rectilinear, and its extremities are smooth and slightly prominent. The specific name has reference to the few long teeth or points that are disposed on the sides, and which are probably intended for the union of several frustules into a series.

Triceratium arcticum, Bright., var. *kerguelenensis*, nov. (Plate XIII. fig. 7.)

The specimen here shown must be regarded as a variety of *Triceratium arcticum*, Bright.,[1] as it only differs from that Diatom in not possessing so markedly concave sides. The cellules or areolæ are also larger than in the typical specimen.

Triceratium arcticum, Bright., var. *kerguelenensis β*, nov. (Plate XXII. fig. 5.)

This frustule is also a variety of *Triceratium arcticum*, Bright. Its radiating rows of granules which spread outwards from the centre, the granules becoming larger and more distinct as they approach the periphery, distinguish it from the Brightwellian species.

Triceratium arcticum, Bright., var. *kerguelenensis γ*, nov. (Plate XIII. fig. 5.)

This triangular form, with concave sides and rounded extremities, was obtained in the neighbourhood of Kerguelen Island. The valve is covered with radiating lines of cellules, which decrease towards the extremities, becoming small granules, arranged in a quincuncial manner. Although thus agreeing in the nature of its cellulation with *Triceratium arcticum*, Bright., it differs from the latter (1.) in the concave character of its sides, and (2.) in the occurrence of a small central non-granulated or smooth area. These distinctions, however, cannot be looked upon as possessing more than a varietal importance.

Triceratium calvescens, n. sp. (Plate IX. fig. 1.)

Grandiusculum, triangulare; lineis lateralibus concavis; apicibus rotundatis; cellulis grandiusculis in lineas radiantes distributis, et ad apices subito in lineolas punctulatas decrescentibus, media valva raris et minuentibus. In mari Japonico.

This form, like *Triceratium arcticum*, Bright., is also covered with radiating granules or somewhat irregular cellules, which quickly diminish as they approach the extremities, and

[1] = *Triceratium wilkesii*, var. *β*, with four angles; *Amphitetras wilkesii*, Brightwell, *Micr. Journ.*, vol. i. p. 250, pl. iv. fig. 11; Roper, *Trans. Micr. Soc. Lond.*, vol. viii. p. 58.

assume the appearance of minute points, forming very delicate striæ. The walls, however, are slightly concave, the general valval granulation larger, while at the centre the granules are few and small, so that the genus established by Brightwell cannot be so far extended as to embrace this form, which must therefore become the type of a new species.

Triceratium pavimentosum, n. sp. (Pl. XIII. fig. 8.)

Quadratim areolatum; lateribus concavis; apicibus cuneato-rotundatis; areolis subhexagonalibus; apicum processu nullo. Ad mare Japonicum.

This frustule possesses concave walls and valves ornamented with subhexagonal cellules or areolæ. It may be distinguished from the allied *Triceratium favus* of Ehrenberg[1] principally by the absence at each extremity of the horn-like processes, which are characteristic of the latter. *Triceratium favus* also possesses rectilinear or slightly concave sides.

Triceratium cariosum, n. sp. (Plate VI. fig. 6.)

Valvis trigonis, cellulosis; lateribus subconvexis; apicibus rotundatis; cellulis æqualibus nullo certo ordine dispositis et vacuis lineolis irregulariter divisis. In mari Pacifico.

This singular Diatom possesses a triangular form, with slightly convex walls and rounded extremities. The cellules that ornament the valve are equal, but have no definite arrangement, although a tendency to form excentric curves may be recognised at some places. Lacunæ occur at irregular intervals amongst the granules, and give the valve an eroded appearance.

Triceratium punctigerum, n. sp. (Pl. XIII. fig. 4.)

Parvum, triangulare; apicibus rotundatis; lateribus subconcavis; denticulo vel punctulo erectiore marginali ad apices; valvis inordinate punctulatis. In mari Pacifico.

This small but elegant triangular Diatom was discovered in a sounding made in the Pacific Ocean. It possesses rounded extremities and slightly concave sides. The valve is very delicately punctated, the punctations assuming no definite arrangement, and at the margin of each extremity a more prominent granule or point may be recognised.

Triceratium coronatum, n. sp. (Plate VI. fig. 7.)

E maximis; triangulare, areolatum; lateribus convexis; apicibus elongatis, subulatis; areolis æqualibus, hexagonis granulo erecto ad quemque angulum; corona marginali erecta. Ad Zebu in mari Philippinarum.

[1] Ehrenberg, Kreideth., p. 79, N. 58, pl. iv. fig. 10; Mikrogeol., pl. xix. p. 17; Smith, Synop. Brit. Diat., vol. i. p. 26, pl. v. fig. 44, and Suppl., pl. xxx.; Heiberg, Conspec., p. 41; Jan. et Rabenh., Hondur., p. 14, pl. iii. fig. 10; = (1.) *Triceratium megastomum*, Brightwell, *Micr. Journ.*, vol. i.; (2.) *Triceratum fimbriatum*, Wallich, *Micr. Journ.*, vol. vi. p. 247, pl. xii. figs. 4–9.

In this very striking frustule a marginal corona exists on one edge. This usually escapes notice, because the flat form of the Diatom prevents it from being recognised, save on the valval side. The form of the entire frustule is triangular, and the margins are convex, while each extremity terminates in an elongated subulate process. The areolæ are hexagonal, and remarkable in having small rounded granules at their angles. This circumstance cannot be considered fortuitous, and, in conjunction with the other characters of the frustule, must be regarded as adequate for the establishment of a new species.

Triceratium sarcophagus, n. sp. (Plate VI. fig. 3.)

Trigonum, lateribus convexiusculis, apicibus cornutis, asperis; valvis convexis, late areolatis vel cellulatis; areolis vel cellulis hexagonis. In mari Arafura.

The specific name of this form is applied from the peculiar appearance presented when seen from its zonal aspect. It is triangular, and possesses slightly convex sides and terminal horn-like processes. In its general aspect it shows some affinity to *Triceratium favus*, Ehrenb., but the areolæ are smaller in the latter, and the terminal processes are not rough, as they are in this frustule.

Triceratium favus, Ehrenb., var. *late-areolata*, nov. (Plate IX. fig. 3.)

This form only differs from *Triceratium favus*, Ehrenb., in having the areolæ one-third larger. It was obtained in the Sea of Japan.

Triceratium favus, Ehrenb., var. *pacifica*, nov. (Plate VI. fig. 1.)

The areolæ in this variety are still larger; the ratio of their size to that of the type-specimen being as 19 to 8. It possesses four concave sides, and a small horn-like process at each extremity. It was obtained in the Pacific Ocean.

Triceratium tumescens, n. sp. (Plate VI. fig. 9.)

Triangularis, lateribus convexis; apicibus cuneato-obtusis; processibus spheroidalibus; valvis areolatis; areolis hexagonalibus, inæqualibus. In mari Japonico.

This triangular form possesses very tumid sides, obtuse extremities and processes, and unequal hexagonal areolæ. It presents a superficial resemblance to *Triceratium fimbriatum*, Wall.,[1] but it may be readily distinguished from it by the character of its terminal processes, which resemble a compressed spheroid, instead of being elevated and conical. It was obtained in the Sea of Japan.

Triceratium armatum, Roper, var. δ, nov. (Plate VI. fig. 2.)

This elegant triangular form from the immediate neighbourhood of Japan is provided with straight sides, and its extremities are notably elongated, forming well-marked subu-

[1] *Micr. Journ.*, vol. vi. p. 247, pl. xii. figs. 4–9.

late processes. The granules, which are of equal size, are arranged in rows at right angles to the margins, but in a central triangular space they are disposed irregularly. The demarcation of this central area is clearly indicated by a few well-marked granules or denticules, placed at intervals along its sides. In the area itself there are a few scattered minute spines or apiculi. In these respects this frustule resembles the *Triceratium armatum* of Roper,[1] but it may readily be distinguished from the latter by the denticules referred to above. Brightwell has already (Quart. Journ. Micr. Sci., vol. iv. p. 274, Plate xvii. figs. 9, 9*b*, 10, 11, 11*b*, 12) notified several varieties of the typical species, and the present form may be similarly referred to as var. *δ*.

Triceratium fimbriatum, Wall., var. nov. (Plate IX. fig. 12.)

This form resembles in its general characters the *Triceratium fimbriatum* of Wallich,[2] but its terminal processes are much more elevated, and its extremities somewhat more dilated.

Triceratium incrassatum, n. sp. (Plate IX. fig. 10.)

Trigonum, areolatum; valva lateribus convexis tumida; areolis hexagonalibus; apicibus obtuso processu terminantibus. In mari Japonico.

This form corresponds in general outline to the *Triceratium grande* of Brightwell,[3] and its hexagonal areolation is also similar. The extremities, however, are here remarkably depressed and obtuse, instead of being more acute and attenuated. The ocelli are nearly in the plane of the valve, which is evidently tumid. The three sides are slightly convex, and the hexagonal areolæ vary somewhat both in size and shape even in the central region of the valve.

Triceratium grunowianum, n. sp. (Plate XVI. fig. 5.)

Forma triangularis, latissime areolata; apicibus aspero processu erecto instructis; areolis subhexagonalibus; valvis finissime et radianter punctulatis; margine convexo lævi. Ad insulas Philippinas.

This Diatom is remarkable from the enormous size of its unequal hexagonal areolæ, its strong terminal processes, covered with inequalities, and its very delicate radiating punctiform striation. The three sides of the valve are slightly convex outwards, and in immediate contact with these is a hyaline belt which bears irregularly elliptical or clavate granules. At the bases of each of the three terminal somewhat infundibuliform processes there are also several irregularly scattered angular granules which serve to give greater prominence to this region. The narrower and more distal parts of each process bears a series of fine striæ which radiate into the proximal and wider end of the funnel. The specific name has been given in honour of Mr Albert Grunow, the well-known observer of Diatoms.

[1] *Micr. Journ.*, vol. ii. p. 283, fig. 1.

[2] *Micr. Journ.*, vol. vi. p. 247, pl. xii. figs. 4–9.

[3] *Micr. Journ.*, vol. i. p. 249, pl. iv. fig. 8; = (1.) *Triceratium orientale*, Harv. et Bail.; (2.) *Triceratium favus* (large), Pritchard, *op. cit.*, p. 856. The original specimens of *Ticeratium grande*, Bright., were found on Tridachnidæ and other shells from the Indian seas.

Triceratium abyssale, n. sp. (Plate XIII. fig. 6.)

Forma orbiculato-triangularis, apicibus late rotundatis, in ocellum exeuntibus; lateribus convexis; valva punctulis æqualibus radianter signata. In mari Indico.

This form possesses large rounded extremities and convex sides, so that the frustule becomes suborbicular. The valve has equal radiating lines of punctations slightly converging at the obtuse apices, each of which terminates in a large ocellus. The specimen was obtained at a depth of 2050 fathoms.

Triceratium insutum, n. sp. (Plate XXV. fig. 7.)

E maximis; valvis novem-angulatis, areolatis; lateribus concavis; areolis hexagonalibus, grandiusculis, inæqualibus; valva exterius areolata, inferius arctissime et radianter striolata. In mari Philippinarum.

This species possesses nine angular points, and between each adjoining pair a concave margin. The surface is covered by very large subhexagonal areolæ, which gradually diminish in size from the centre towards the periphery. The valve exhibits fine radiating striæ, and the areolæ present at the bottom irregularly rounded spaces, which bear one or more distinct and irregularly disposed granules or points. It appears certain that these two kinds of ornamentation belong to two distinct strata of the diatomaceous cell wall, which may sometimes become detached from one another. I became convinced of this when Dr James Rae, R.N., drew my attention to a *Triceratium* in which only a part of the inner striated layer still adhered to the valve. A similar doubly laminated wall may be seen in *Triceratium favus*, Ehrenb., and in *Triceratium grunowianum* above referred to; but the nine-angled frustule now in question cannot be united with these, not only because of the little points in the centre of the areoles, but still more because of the absence of the raised terminal processes which are presented by the others.

In consequence of this bilamination of the frustular wall, it becomes necessary to exercise great caution in the establishment of new species of this genus.

Triceratium atlanticum, n. sp. (Plate XVII. fig. 3.)

Forma quadrato-globosa, cellulis grandiusculis a quinque majoribus mediis radiantibus, et leviter ad quatuor ocellos terminales convergentibus. In Oceano Atlantico ad insulas Azores.

This specimen possesses four very obtuse angles, between each of which the sides are convex, so that the resulting form is suborbicular. The cellules are of somewhat large size, and radiate from a small central rosette formed of five large cellules. Each of the angles presents an elliptical ocellus, and towards each of the four extremities the cellules become slightly convergent.

The specimen figured was obtained in a sounding made near the Azores in the Atlantic Ocean.

Stictodiscus, Grev.

This genus was established by Greville in a communication read on 12th March 1861,[1] and he classed in it *Discoplea* (?) *rota*[2] and *Discoplea rotula*,[3] Ehrenberg, as well as *Actinoptychus dives*,[4] which, as already suggested by Ehrenberg, might be generically associated with *Cyclotella rota* and *Cyclotella rotula*. The words of Ehrenberg are (under his definition of *Discoplea* (?) *rota*): "Proxime ad *Actinoptychum divitem* in Græcia fossilem accedens forma, et cum ea forsan, et cum sequente (*Discoplea* (?) *rotula*) in peculiari genere reponenda."

To this genus Greville at this time ascribed six species, and later Kitton[5] made us acquainted with *Stictodiscus crozieri*. Grunow[6] added his *Stictodiscus angulatus* in the Typenplatten of Möller, while Cleve[7] announced his *Stictodiscus novaræ* in a paper communicated to the Royal Swedish Academy of Science on 15th September 1880.

The definition of the genus *Stictodiscus*, as given by Greville, ran as follows:—"Frustules simple, discoid, divided by radiating lines into numerous plicate compartments. Lines not reaching the centre. Compartments furnished with conspicuous transparent, pore-like points. (In the four typical species, large scattered puncta also occupy the blank central portion of the disc.)"

Among the materials collected by the Challenger Expedition a considerable number of specimens of *Stictodiscus* has been observed, but these were only found in a few localities, the most noteworthy of which are the Japanese coast and Zebu in the Philippine Islands. The examination of these specimens has convinced me that the structural peculiarities, and particularly the folded compartments, are somewhat variable and do not always afford sufficient ground for establishing new species. All the forms may be reduced to two principal sections, namely (1.) *radiate Stictodisci*, in which the discs possess compartments and the folds are simply radiating; and (2.) *radiato-areolate Stictodisci*, in which the discs have radial folds which proceed from the circumference, but soon bifurcate or are interrupted so as to bound numerous polygonal areas. It is to be noted, however, that this classification, though of use in facilitating the description of forms so similar to

[1] *Micr. Journ.*, n. s., vol. i. p. 39.

[2] *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1844, p. 202; Mikrogeol., pl. xxxv. A 22, fig. 6.

[3] Ehrenberg, Mikrogeol., pl. xxxv. A 22, fig. 7.

[4] Ehrenberg, Mikrogeol., pl. xix. fig. 12; Ralfs in Pritchard's History of the Infusoria, 4th ed., p. 840.

[5] *Micr. Journ.*, 1873, pl. xxxviii. fig. 2.

[6] In Schmidt's Atlas (explanation of plate lxxiv. figs. 26–30), a note is appended to Grunow's *Pseudostictodiscus angulatus* to the following effect: "Grunow bemerkt dazu, die beiden Schalen seien nicht ganz gleich, die flachere habe keine Rippen, und immer in der Mitte einen rudimentären Stachel, der in meinen Zeichnungen fehle; die Ecken etwas vorspringend, darum den Biddulphien sich nähernd."

[7] *Kongl. Svensk. Vetensk.-Akad. Handl.*, 1880, Bd. xviii. No. 5, p. 21, pl. v. fig. 66.

one another as those belonging to this group are, cannot be rigorously applied, since, for example, in *Stictodiscus buryanus*, Grev.,[1] the radiating appearance is still retained by the valve, although some of the radial folds are found to be interrupted.

Again, the *radiate Stictodisci* may be divided into two groups according as the central area is or is not distinguished by a simple or double corona of fine points or granules, and these groups may be indicated as *coronate* or *non-coronate* respectively.

It must further be remarked that among triangular frustules having the very greatest affinities to *Triceratium*, some have been observed which, with the exception of their non-discoidal form, exactly fulfil all the conditions of structure required by the definition of *Stictodiscus* as given by Greville. Thus among the triangular specimens brought home by the Challenger, one had its surface folded in a radiating manner, and also showed the central Stictodiscoid corona of points, so that notwithstanding its non-discoidal form it must still be regarded as a true *Stictodiscus*. On this ground, therefore, the generic definition as given by Greville should be modified, and may be stated in the following words :—"Frustula simplicia, discoidalia, vel polygonalia, per lineas radiantes divisa in areas plicatas, lineis centrum non attingentibus; areis plerumque conspicuis punctis vel granulis instructis."

We cannot, indeed, believe that the same species can assume sometimes one form and sometimes another, or that from the same *Stictodiscus* sometimes discoid and sometimes triangular or polygonal forms arise—before admitting such an anomaly it would be necessary to have the experimental results of artificial cultivation of some given species to go upon—yet from their structural characteristics I must conclude that a *Stictodiscus* may exist as a discoid or triangular or even polygonal body. The two last groups of forms may be indicated by adding to the specific name the words *forma triangularis* or *forma polygonalis* respectively.

Having arrived at the conclusion stated above, it seems a fitting occasion to review the long series of species of *Triceratium* to determine whether any of these forms might not more properly be relegated to our present genus.

Greville in 1861[2] described under the name of *Triceratium harrisonianum* a magnificent triangular form adorned with rows of pearl-like puncta, which formed a large circumscribing belt. This frustule, moreover, was provided with sparsely disposed pearl-like granules in the central space, in which there also occurred a conspicuous network of large elongated radiating cellules from which lines passed outwards between the rows of granules to the margin. But on examining the figure the cellules in question are areas or compartments which are bounded by *depressed* lines that pass between the rows of granules, and not by lines of relief as might readily be inferred from the bold manner in which they are represented in Greville's figure. The fact that Greville had not found examples belonging to any genus which had sometimes a discoidal, sometimes a triangular

[1] *Micr. Journ.*, n. s., vol. i. p. 40, pl. iv. fig. 1.
[2] *Micr. Journ.*, n. s., vol. i. p. 76, pl. ix. fig. 9.

or polygonal form, prevented him from recognising affinities between two groups of forms so distinct from one another, and although from the disposition of the granules, in lines radiating from the sides and sparsely disseminated in the centre, he thought of constituting a special group for *Triceratium harrisonianum* and *Triceratium margaritaceum*, Ralfs, he was unaware of the importance of the folded character of the former, which, taken in conjunction with the special distribution of the granules, should have induced him to class it with *Stictodiscus*.

Again, Greville[1] determined as *Triceratium inflatum*, a three-sided form furnished with lines or veins radiating from the margin to the middle of the radii, and possessing puncta or granules which were large and sparsely disposed in the central part, but smaller and more numerous on the circumference. These characters, however, are precisely those of the genus *Stictodiscus*, so that the organism should be named *Stictodiscus inflatus*.

The name *Triceratium lineolatum*, Grev.,[2] cannot, however, be corrected in the same manner, because though in this veins or folds occur on the plane of the valve at its margin, the valve is elsewhere covered throughout with equal, minute, radiating granules —a character which I have never met with in any of the different specific forms of *Stictodiscus*.

That, on the other hand, *Triceratium parallelum*, Grev.,[3] is a true *Stictodiscus* cannot be doubted. It possesses four or six angles, its centre is areolated by furrows or folds which are distributed in a retiform manner, and its border is furnished with granules disposed in radiating lines. It should therefore be named *Stictodiscus parallelus*.

To the same genus should also be ascribed *Triceratium quadratum*, Grev. (*loc. cit.*, fig. 19), because it shows short folds at the circumference, and the surface is covered with radiating lines of granules, which however are few, and scattered in the central space. It may also be observed that Greville reports having seen specimens with a sort of umbilicus, or, at least, a somewhat irregular circle of smaller cellules, around which the ordinary cellules are often more or less scattered before they pass into radiating lines—a circumstance which would seem to indicate that the frustule in question is a *coronated Stictodiscus*.

In the case of *Triceratium polygonium*, Grev.,[4] we have to deal with a true *Stictodiscus*. This beautiful Diatom, with its six straight sides and obtuse angles, not only possesses elegant lines of radiating granules except in the centre, which is slightly reticulate, but, as shown in the figure, as many depressed lines or folds as exist in the recognised forms of *Stictodiscus* occur at the margin. The name should accordingly be changed to *Stictodiscus polygonius*.

The *Triceratium quadricorne* of Greville[5] is also probably a *Stictodiscus*, as its surface

[1] *Micr. Journ.*, n. s., vol. iii. p. 232, pl. x. fig. 15.
[2] *Micr. Journ.*, n. s., vol, iii. p. 233, pl. x. fig. 16.
[3] *Micr. Journ.*, n. s., vol. v. p. 104, pl. ix. figs. 22 and 23.
[4] *Micr. Journ.*, n. s., vol. v. p. 105, pl. viii. fig. 14.
[5] *Micr. Journ.*, n. s., vol. v. p. 103, pl. ix. fig. 16.

is marked by many areas or compartments which are limited by folds or depressed lines, while each compartment is ornamented by a pointor granule—the latter character being one of the chief distinguishing features of the genus *Stictodiscus*. It is true that here no radiating folds occur at the circumference, and that the granules are more dense at the edge than at the centre; hence the frustule should probably be designated *Stictodiscus quadricornis*, although its precise determination must remain somewhat uncertain.

Professor Cleve, in his communication On Some Rare and Little-Known Diatoms,[1] has described two forms under the name of *Triceratium*, which, in my opinion, are also true *Stictodisci*. The first—*Triceratium gallapagense*, is shown in his plate vi. fig. 72. It is a triangular acute-angled form, with granules sparsely scattered in the middle, but more densely disposed at the sides, where they form short rows, while fine branching lines of more simple points are seen at the angles. In the figure the few radiating lines which are indicated evidently denote the characteristic folds of *Stictodiscus*. It should accordingly be designated *Stictodiscus gallapagensis*. It is distinguished from my *Stictodiscus bicoronatus* specifically by the absence of the central corona.

The second form referred to by Cleve as *Triceratium margaritiferum* (*loc. cit.*, pl. vi. fig. 76) is a *coronated Stictodiscus*. It has been described by Cleve as follows :—"Valve quadrangular, with concave sides and rounded angles, without processes. Surface probably plane. Structure tolerably coarse, granules arranged near the margins in short lines, smaller in the angles, rare and scattered in the middle." In the centre of the figure there is also seen a small corona of points which has been omitted in the above description. By examining the various figures which I have given of new species of *Stictodiscus*, the very close affinity of this species of Cleve is at once apparent, although the folded condition of the valve in the latter is not evident. Hence this frustule should be named *Stictodiscus margaritiferus*.

The above remarks on *Stictodiscus* and *Triceratium* were finished when the nineteenth part of Schmidt's Atlas of the Diatomaceæ was published. In that work very good figures are given on plate lxxiv. of several new species of *Stictodiscus* as well as of some already known, and on plates lxxv. and lxxvi. numerous types have been represented as belonging to the genus *Triceratium*, among which I at once recognised many real polygonal *Stictodisci*. Among the known discoidal forms *Stictodiscus hardmanianus*, Grev., is shown on plate lxxiv. fig. 8, in a somewhat small form; *Stictodiscus kittonianus*, Grev., is seen in figs. 16, 17, and 18; while *Stictodiscus californicus*, Grev., occurs as fig. 4, and several varieties as figs. 1, 2, 3, 6, 7, and 9.[2] Among the new species, on the other hand, *Stictodiscus simplex*, A. S., is shown in fig. 11; *Stictodiscus*

[1] *Kongl. Svensk. Vetensk.-Akad. Handl.*, Bd. XVIII. No. 5, p. 25, pl. vi. fig. 72.

[2] These varieties are—*Stictodiscus californicus*, Grev., var. *areolata*, Grun., pl. lxxiv. fig. 1.
Stictodiscus californicus, Grev., var. *nankoorensis*, Grun., pl. lxxiv. figs. 2 and 3.
Stictodiscus californicus, Grev., var. *ecostata*, Grun., pl. lxxiv. figs. 6 and 7.
Stictodiscus californicus, Grev., pl. lxxiv. fig. 9.

argus, A.S., in fig. 12; and finally, *Stictodiscus morsianus*, A. S., in figs. 19 and 20. The forms marked figs. 21, 22, and 23 are given as doubtful, while those of figs. 13, 14, and 15 are interpreted as internal valves[1] of *Stictodiscus*—a determination which seems to rest on no other foundation than the presence of evanescent folds towards the centre, there being no trace of any such reticulate arrangement as occurs in *Stictodiscus*. It would seem rather that such discs belong to the genus *Cyclotella*, of which they would constitute a new species.

On plate lxxv. fig. 1, Schmidt has represented a superb polygonal *Stictodiscus* under the name of *Triceratium multiplex*, Janisch (?). It possesses a central corona, and the almost regular short lines of granules form a belt at the circumference, while the middle of the surface is covered with sparsely disposed granules of a similar kind. The very large valve, which has arrived at its complete development, scarcely preserves traces of the folded condition of its surface, but I do not hesitate to designate it *Stictodiscus multiplex*.

In fig. 2 of the same plate the organism represented as *Triceratium jeremianum*, A. S., is another subquadrate *Stictodiscus* with subradiating folds which alternate with granular lines, that subsequently become rare and are irregularly scattered in the middle. Many lines of small granules occur at the angles, and these point, as in other allied forms, to its progressive development. This form should accordingly be designated *Stictodiscus jeremianus*.

At figs. 6 and 7 Schmidt also shows two different forms of *Triceratium*, established by Greville, which, as already said, must be named *Stictodiscus eulensteinii*; while the *Triceratium harrisonianum*, Grev., shown at Plate lxxv. figs. 14 to 16 should be designated *Stictodiscus harrisonianus*.

On plate lxvi. of this Atlas several other forms which have been named *Triceratium* appear to me to be true *Stictodisci*, although the essential characters of the latter genus are in these less evident than in the above-mentioned cases.

In considering the new types belonging to the genus *Stictodiscus* which have been brought home by the Challenger I shall first refer to the discoidal forms, and then pass on to those which are polygonal.

I. Discoidal Forms of Stictodiscus.

Stictodiscus anceps, n. sp. (Plate I. fig. 5.)

Granulis raris in lineas subregulares radiantes distributis; centrum punctulorum corona distinctum. Ad oras Japonicas.

[1] "Nach meiner festen Ueberzeugung *innere Schalen* v. *Stictodiscus*. Solche innere Schalen, welche namentlich bei *Asteromphalus* und *Asterolampra* vielfach vorkommen und irrthümlich als besondere Arten benannt sind, sind leicht daran zu erkennen, dass sie theils einen Stich ins Violette haben theils der feineren Sculptur ermangeln, überhaupt roher gestaltet sind. Grunow bestimmt die vorliegenden Figuren als Schalen von *Melosira claviyera*, Grunow."

This elegant disc is ornamented at the margin with sparsely disposed lines of granules. These become irregular towards the centre, and are replaced there by an irregular corona of small points. The presence of this corona has induced me to include this frustule among the *Stictodisci*, although the folded condition of the valve, which is the principal generic character, could not be distinguished. It is to be noted, however, that in the different species the folds are found more or less clearly defined, and when they are very slight they become almost invisible, so that the impossibility of recognising them here is not necessarily opposed to the determination that has been arrived at.

Stictodiscus radiatus, n. sp. (Plate I. fig. 1.)

Granulis in lineas radiantes plicis divisas distributis; plicis ad centrum evanescentibus; centrum granulis caret. Ad Zebu ex insulis Philippinis.

This frustule, and its variety shown in Plate I. fig. 3, belong to the radiate section of the genus *Stictodiscus*. They are closely related to the *Stictodiscus californicus* of Greville,[1] which in its turn is akin to *Stictodiscus johnsonianus*, Grev.,[2] differing from it in the indistinct and shorter radii, and in the condition of the peripheral zone from which these radii spring. This zone is marked in *Stictodiscus johnsonianus* by a series of round or somewhat elliptical granules which are situated opposite the peripheral ends of the radii, while in *Stictodiscus californicus* it bears semi-elliptical areolæ which usually alternate with the radii. In the forms now under examination, on the contrary, the radii are notably long and the centre always remains free from granules, while the great number of the radii—although by itself a character of no great significance—cannot be overlooked.

Although the type-specimen shown in Plate I. fig. 1 bears a great resemblance to its variety seen in fig. 3 there are some differences which must be noted. Thus in addition to the greater number of granules which are radially disposed and ornament the valves in fig. 3, there is also present here a somewhat prominent granule at the extremity of each fold, and the radii begin with two small granules. In the course of the radii each granule is elevated upon a subrectangular areola. Much importance cannot be attached to the granules at the extremities of the folds, as their existence is doubtful in some cases—similar appearances often occurring at the margin of the valve in changing the focal distance. The subdivision of the radii into compartments serves to indicate the connection between the *radiate* and *radiato-areolate* forms of *Stictodiscus*. The following definition may be given of the varietal frustule:—"Lineis crebriusculis granulorum in areas rectangulares, granulum in margine ad ortum cujusque plicæ. Ad oras Japonicas."

Stictodictus eulensteinii, Cstr. (Plate I. fig. 7.)

Triceratium eulensteinii, Grun., A. Schmidt's Atlas, pl. lxxv. figs. 6 and 7.

In Plate I. fig. 7 there is represented an exceedingly elegant form of *Stictodiscus*, which indicates the transition from the *discoidal* to the *triangular* and *polygonal* types.

[1] Schmidt's Atlas, pl. lxiv. fig. 4. [2] *Micr. Journ.*, n. s., vol. i. p. 41, pl. iv. fig. 3.

It possesses the form of a disc with an undulating (almost dodecahedral) margin. A triangle of smaller granules occurs in each of the protuberances, and hence I am of opinion that the frustule originally was discoid, and that its subsequent development did not take place uniformly all round the circumference, but only in a few circumscribed areas. During this process small granules have been formed; these have gradually increased in size and become disposed in the large regular lines, which occupy the spaces lying between the protuberances. A similar condition obtains more or less markedly at the extremities of triangular frustules, as will be pointed out below.

Between the lines of the quadrately disposed granules radiating folds arise and extend towards the centre. The compartments circumscribed by these folds are furnished with sparsely arranged granules, and a beautiful corona of smaller points occupies the centre.

After this frustule had been figured and described I received the nineteenth part of A. Schmidt's Atlas, in which the same form is figured at Plate lxxv. figs. 6 and 7, under the name of *Triceratium eulensteinii*, Grun. Although therefore recognising the right of precedence of the well-known Austrian microscopist in the case of the specific determination, I cannot accept his generic name, but assign the organisms, for reasons already quoted, to the genus *Stictodiscus*. The frustule was gathered both in the Sea of Japan and in the Philippine Sea.

Stictodiscus radfordianus, n. sp. (Plate XVII. fig. 10.)

Forma octogona, lineis undulatis, et angulis subproductis rotundatis inclusa; zona regulari ordine quadrato granulata, plicis a margine radiantibus; granulis medio raris; punctulorum corona umbilicali. In Archipelago Philippinarum.

This frustule, which is still more elegant than that last referred to, belongs to the *coronate* section of the genus. It possesses an octagonal form with undulating sides, while the angles are rounded and scarcely elongated. A belt formed of four regular rows of granules runs round the periphery of the valve. These granules are disposed in a quadrate manner, and folds extend between them in a centripetal direction. In the middle region small granules are sparsely disseminated, and the centre is marked by a beautiful corona of small points. Here too, as in the case of *Stictodiscus eulensteinii*, rows of small granules occur at the angles, and as in the former case seem to indicate points of gradual increase.

The specific name has been given in honour of Dr Radford, to whom, in part, I am indebted for being invited to examine the Diatoms brought home by the Challenger Expedition.

II. Radiato-Areolate Forms of *Stictodiscus*.

In all these types, folds of greater or less length radiate from the circumference towards the centre, and the central space is subdivided into areoles in a reticulate manner.

Stictodiscus japonicus, n. sp. (Plate I. fig. 2.)

Granulorum lineis per plicas radiantes divisis prope marginem binatim orientibus; areis mediis grandiusculis reticulatim dispositis singulo granulo plerumque distinctis. In mari Japonico.

This organism may be distinguished from the others by the circumstance that in it the granules do not occur on the perimeter, while there are always two granules standing side by side at the outer extremity of every row. The central areas are somewhat large, of irregular forms, and are in most cases ornamented with a single granule.

Stictodiscus affinis, n. sp. (Plate I. fig. 4.)

Lineis granulorum per plicas circumradiantes divisis; media superficies in areolas reticulatim distincta; areæ nonnullæ granulo instructæ. Ad Zebu in mari Philippinarum.

This form is much akin to the preceding, but may be distinguished from it by the fact that the lines of granules proceed from the margin—a peculiarity which may also be seen in the variety described below. The two granules found at the outer ends of every row in *Stictodiscus japonicus* do not occur here, where, moreover, the central areas are of smaller sizes and somewhat more abundant. Although the majority of these areas are ornamented by a single round granule, some of them are entirely devoid of this structure, while others bear two.

Stictodiscus affinis, n. sp., var. nov. (Plate I. fig. 6.)

Differt a forma typica per lineas binis granulis ter vel quatuor vicibus repetitis incipientes. Ad mare Philippinarum.

In this Diatom the granule-bearing areas sometimes exhibit four pairs of puncta towards the circumference of the disc. The central areas are somewhat irregular in size and form, and while several are perfectly smooth others bear a single round granule. Hence although not identical with the Zebu type, this frustule cannot be regarded as more than a variety of it.

Stictodiscus affinis, n. sp., var. *late-zonata*, nov. (Plate XVII. fig. 11.)

Although well characterised by its distinct granulated zone, this Diatom must be viewed as a distinct variety of *Stictodiscus affinis*. It is principally distinguished by the marginal radiating folds, which become reticulated towards the centre, and by the distinct and regular lines of granules interposed between the folds. Marginally the granular lines are ornamented by pairs of puncta placed laterally. Two well-defined rings of approximately equal size run round the periphery.

Stictodiscus affinis, n. sp., var. nov. (Plate XVII. fig. 8.)

Another variety of the same species is here shown. The smallness of its disc and the smaller number of its radii can certainly have no specific significance, but it may be

observed that the reticulated central space is almost destitute of granules. This variety, like the previous one, was collected in the neighbourhood of the Philippine Islands.

Stictodiscus reticulatus, n. sp. (Plate I. fig. 8.)

Lineis granulorum plerumque per plicas a margine radiantes distinctis; hinc plicæ reticulatim distribuuntur; areæ centrales grandiusculæ, pluribus granulis plerumque instructæ. Ad Zebu.

This disc is ornamented with lines of granules which are for the most part double. These lines are separated by folds which soon become reticulated after leaving the margin. The meshes of the well-marked somewhat irregular network thus formed are adorned with more or fewer granules, disposed in small groups. The frustule was obtained at Zebu.

Stictodiscus margaritaceus, n. sp. (Plate XVII. fig. 12.)

Disciformis, granulis plerumque magnis, medio raris, ad marginem frequentioribus, et subregulariter dispositis; plicis a granulo marginali exeuntibus et granulorum lineas discriminantibus. Ad insulas Philippinas.

In this specimen the granules are unusually large and pearl-like. They are sparsely scattered in the centre and more closely near the margin, where they are divided by slight folds, each of which originates in a well-marked marginal point. The disposition and size of the granules are inconstant.

III. Triangular or Polygonal Forms of *Stictodiscus*.

Stictodiscus varians, n. sp. (Plate XVII. fig. 7.)

Forma subquadrata, lateribus convexis; granulis a margine radiantibus, medio rarioribus et irregulariter distributis; lineæ marginales plicis evanescentibus dividuntur. In mari Sinensi.

This specimen is, in form, transitional between the round and the polygonal types. The discoidal valve tends to become angulated at four points in such a manner that by a further extension of the angulation the round form would become quadrate. The disposition of the granules is regular and somewhat dense at the circumference, but rare and irregular at the centre. At the perimeter the lines of radiating granules are intersected by folds, which soon disappear. The specific name which has been applied is intended to recall the tendency to vary in form from round to quadrate which is exhibited by this interesting Diatom.

Stictodiscus bicoronatus, n. sp. (Plate VI. fig. 5.)

Trigonus, lateribus subconvexis et apicibus rotundatis; zona granulis raris et decussatim dispositis; granulis medio nullo certo ordine distributis; centrum duplici punctulorum corona insignitur; ad apices multiplæ punctulorum lineæ radiantes. Ad oras Japonicas.

This beautiful triangular frustule, from the neighbourhood of the coast of Japan, has slightly convex sides and rounded angles. The granules are disposed at right angles to each of the margins along regular lines, and so form a well-marked peripheral belt which circumscribes a central triangular space ornamented with irregularly disposed granules, very minute points, and short irregular wavy lines, but in the centre two coronæ of smaller granules occur. At the three rounded angles of the triangle the regular lateral granulation is replaced by many lines of small points, which are arranged in a fan-like manner. Although no folds are to be found in this species its fundamental Stictodiscoid character is indicated (1.) by the peculiar disposition of the granules along the sides; (2.) by the general character of the granulation, which recalls that of *Stictodiscus anceps*, n. sp.; (3.) by the presence of central coronæ; and (4.) by the general similarity of the granulation of the angles to that of the twelve salient points of *Stictodiscus eulensteinii*.

The specific name has reference to the existence of a double corona at the centre of the valve.

Stictodiscus bicoronatus, n. sp., var. *punctigera*, nov. (Plate XIII. fig. 2.)

This is another triangular Diatom which recalls the general characteristics of the preceding, except that it possesses cuneate rounded extremities, punctiform granules, and a more regular double corona of small points. The marginal granules, though small, are arranged in well-defined lines, which are not sharply limited on the inner side. The granules occupying the subcentral area are irregularly and very sparsely disseminated. Inside of the double corona no granules occur. These characters, however, do not seem to be of sufficient importance to justify the establishment of a new species.

The name of this variety is intended to recall the elegant character of the valvular punctation.

Stictodiscus elegans, n. sp. (Plate XIII. fig. 3.)

Forma triangularis lateribus subrectis; plicæ a lateribus radiantur, medio reticulatim dispositæ; granulis raris ordinate circum distributis, medio rarioribus et inordinatis; ad apices rotundatos punctulorum lineæ crebræ radiantur. In mari Japonico.

This beautiful triangular frustule has the marginal rows of granules separated by folds, which become reticulate in the centre. In the central area the granules are sparsely and irregularly disposed, while the three rounded extremities are occupied by radiating lines of small points. Each of the margins is ornamented by a band of oval granules, which are largest in the middle, and gradually become finer towards the extremities. These may indicate a kind of elevated marginal corona, such as is found in some species of *Triceratium*. The external limiting line of this frustule is very slightly convex on its outer side.

Stictodiscus trigonus, n. sp. (Plate XIII. fig. 1.)

Forma triangularis, apicibus obtuso-rotundatis, lateribus tumidulis; granuli medio irregulares et rariores, ad latera lineis per plicas separatis, ad apices punctuli densiores. In mari Japonico.

The slightly tumid sides, and obtuse, rounded angles of this form are noteworthy. The granules are few, and irregularly placed in the centre, but are more abundant and arranged in lines divided by folds at the sides, while they are smaller and still more numerous at the extremities. The gradually decreasing size of the granules from the centre towards the periphery is a well-marked characteristic of this Diatom.

Stictodiscus hexagonus, n. sp. (Plate XVII. fig. 17.)

Valvis hexagonis, granulatis; apicibus late rotundatis; margine granulorum ordine terminato; granulis grandiusculis circum subregularibus, medio nonnullis; superficies medio plicata. In Atlantico septentrionali.

The present curious hexagonal frustule has very rounded angles, and a line of small round granules at the extreme border. The convex surface is flattened at the margin, and is ornamented medially by large granules. These occur in sparsely disposed subregular lines at the periphery, but are almost entirely absent in the centre, where the surface is reticulate, the meshes of the network being very variable in size and irregular in form. At the angles a few closer lines of granules are to be observed. These are disposed in a fan-shaped manner, as in all the polygonal forms of the genus. An intra-marginal thin line, almost parallel throughout to the edges of the frustule, forms a well-marked boundary line between the peripheral and intermediate areas, on the latter of which a reticulation such as is found at the centre is not manifest.

Stictodiscus hexagonus, n. sp., var. nov. (Plate XVII. fig. 14.)

A variety of the last-mentioned type is here represented. It differs from the typical frustule in the smaller size of the disc and granules, in the relatively larger size of the central network, and in the total absence of those lines of small granules that constitute the margin of the valve of *Stictodiscus hexagonus*. Both the frustules were found in the South Atlantic.

Cestodiscus, Grev.

This genus was instituted by Greville[1] in 1865 to include some very elegant discoidal frustules, which differed from *Eupodiscus* only in possessing numerous marginal processes instead of a few. It greatly resembles the genus *Aulacodiscus*, and might, indeed, be identified with it if the intra-marginal shortly tubular processes of the latter were not connected with the centre by means of a distinct furrow formed by a well-defined interval

[1] *Trans. Micr. Soc. Lond.*, n. s., vol. xiii., p. 2.

occurring between two of the radiating lines of granules which proceed from the submarginal processes and run towards the centre.

Greville defines the genus *Cestodiscus*[1] as follows :—"Frustules disciform (circular or oval), disc with radiating granules or cellules, and a submarginal circle of obtuse processes unconnected by means of special radiating lines of cellules with the centre."

To this description the following character, which may be constantly observed in all specific forms, should be added, namely, the radiating granules or cellules of the central part of the disc become more or less abruptly minute crowded granules or points, on approaching the margin. This may be well seen in *Cestodiscus trocos* described below.

Cestodiscus trochus, n. sp. (Plate VII. fig. 1.)

Valvis rotundis ; distinctorum granulorum radiis a centro dimanantibus, pluribus brevioribus insertis ; granulis rotundis, distinctis, æqualibus, ad marginem sensim diminuentibus et stipatis ; ad extremum plurium (32) denticulorum extat corona. In oceano Pacifico.

In this beautiful disciform Diatom there is a group of small, somewhat sparsely disposed granules in the centre, and from this region a series of distinct radiating lines of granules pass out towards the periphery near to which other shorter lines are interposed between these. The granules are usually large and equal, but become smaller near the margin, and finally in a narrow marginal belt become extremely fine and crowded so as to present the appearance of very delicate striæ. Around the striated border very small processes occur. These are irregularly disposed, and accordingly divide the circumference irregularly. They are thirty-two in number in the specimen figured. The specific name[2] has reference to the wheel-like appearance presented by the larger radiating granules that form lines across the valves.

Cestodiscus trochus, n. sp., var. nov. (Plate VII. fig. 3.)

A variety of the preceding species is here shown. It differs from the typical form (1.) in the size of the granules, which are larger ; (2.) in the condition of the centre, which is marked by a small irregular group of somewhat smaller granules ; (3.) in the smaller number—twenty-four—of denticules in the submarginal corona ; and (4.) in the more abrupt change in the size of the granules at the border, where they assume the appearance of minute striæ. The general aspect of the two frustules, however, is the same, and the above distinctions cannot be looked upon as of specific importance.

Cestodiscus convexus, n. sp. (Plate VII. fig. 6.)

Forma rotunda, convexa ; grandiusculorum granulorum ordinibus ab umbilicali area dimanantibus, et continuo crebrescentibus ; ad marginem granuli minuuntur mensura,

[1] *Trans. Micr. Soc. Lond.* n. s., vol. xiii., 1865, p. 48.

[2] τροχός, a wheel.

augentur numero; corona viginti-quatuor denticulorum in marginali limbo arctissime striato. In oceano Pacifico.

The centre of this magnificent disc presents a small, smooth, irregular area, to which radiating lines of equal round granules converge on all sides. Some of these lines become interrupted as they pass inwards, owing to the diminution of the size of the space, and where such interruptions occur, long triangular spaces become interpolated. Near the margin the granules suddenly diminish in size, and assume the appearance of very minute radiating striæ. Twenty-four denticules project around the broad border. Although this Diatom does not seem to differ much from the two preceding, the small irregular umbilical area, and the notable convexity of the valve, point to its true specific character. In addition to the figure of the valve from the valval aspect a small ideal figure from the zonal side has been added in order to show the notable convexity of this frustule.

Cestodiscus coronatus, n. sp. (Plate VII. fig. 9.)

Disciformis, medio granulatus, ad marginem striatus; centrum a margine dividitur per coronam e cellulis oblongis, grandiusculis, a qua exterius oritur denticulorum series. In mari Pacifico.

In this Diatom, which also belongs to the group having a continuous system of granulation and a small umbilical area, the beautiful granulation radiates from a small umbilical area in the central part of the valve, while the margin is ornamented with delicate striæ. The two areas, which are thus differently sculptured, are separated by means of a corona of beautiful large oblong cellules, from which a series of spines or denticules pass towards the circumference. Apart from these denticules the other structural details recall those of the genus *Brightwellia*, Ralfs.[1]

Cestodiscus gemmifer, n. sp. (Plate II. fig. 7.)

Disciformis; granulis rotundis; grandiusculis; circumconfertis, radiantibus, ad aream centralem raris et irregulariter distributis, æqualibus, ad marginem minuentibus et adspectum zonæ marginali striolatum tribuentibus; spinæ vel denticuli plures (38) marginales. In oceano Pacifico.

This large form has a disc about $\frac{1}{17}$ of a millimeter in diameter. It is ornamented by large round granules, which are crowded towards the periphery, but rare and scattered about the centre. These granules gradually diminish in size near the marginal zone, and finally assume the appearance of fine radiating striæ. The spines which project around the margin are more numerous than usual, being thirty-eight in number in the specimen figured. The peculiar irregular distribution of the large granules in the middle area, and the large smooth central space are, however, the chief distinguishing features of the present frustule.

[1] *Micr. Journ.*, n. s., vol. i., 1861, p. 74.

Cestodiscus gemmifer, n. sp., var. nov. (Plate VII. fig. 7.)

The frustule here shown can only be regarded as a variety of *Cestodiscus gemmifer*, n. sp. It differs from the latter (1.) in the character of its granules, which are smaller and are sparsely and irregularly disposed in the centre, from which they radiate towards the circumference, leaving at first smooth alternating areas between the radii, but becoming crowded more peripherally, and finally diminishing, so as to give a striated appearance to the border; (2.) in the greater number—forty-eight—of its denticules; and (3.) in the narrower condition of the border, so that the denticules are placed nearer to the margin.

Cestodiscus gemmifer, n. sp., var. *decrescens*, nov. (Plate XII. fig. 11.)

This variety of the same typical *Cestodiscus gemmifer* may be distinguished from the latter in the following respects: (1.) The granules are large in the centre, and diminish towards the margin; and (2.) the periphery is ornamented with a quincuncially disposed granulation, while the outermost belt is very delicately striated.

Cestodiscus parmula, n. sp. (Plate VII. fig. 5.)

Valvis rotundis, granulatis; granuli potiores vel margaritæ e centro irregulari radiantes, quandoque spatiis intercedentibus, ad marginem confertæ et subito in strias exeuntes; ad zonam marginalem latam in plures circulos distinctam pauciores spinæ vel denticuli distribuuntur. Ad Oceanum Pacificum.

This frustule is especially distinguished by the extraordinary size of the round granules. The smooth umbilical area is absent, being replaced by one ornamented with a few large granules, and from this radiating granulated lines pass towards the periphery. Between these lines bare spaces may sometimes be observed, while secondary granulated lines become interpolated towards the peripheral ends of the former, and finally the granules become contiguous before passing abruptly into the condition of fine striæ. The convexity of the central part of the disc is moderate, and the margin—the inner part of which carries a considerable number of denticules—is broad and divided into several distinct concentric circles. It thus resembles one of the shields[1] used in warfare by the ancient Romans, a circumstance which has suggested the specific name that has been adopted.

Cestodiscus (?) rapax, n. sp. (Plate XVIII. fig. 2.)

Forma rotunda, parva, circum convexa, medio concava; cellulis æqualibus, medio radiatim, in margine decussatim dispositis; pluribus (11) apicibus circum radiantibus, et ad instar ungularum assurgentibus.

This type differs greatly from all the previously mentioned *Cestodisci*, and its generic determination must for the present remain doubtful. Its form is discoid, its centre con-

[1] *Parmula*, a small round shield.

cave, and its marginal portion notably convex. The central area is ornamented with round radiating granules, while the broad margin has these arranged in a decussate manner. From the border of the central concave part there extends to the peripheral ring a series of eleven strongly marked radiating areas, which are raised above the plane of the valve.

Although this singular valve differs from any of the other specific forms of *Cestodiscus*, its characters still coincide with those expressed in the definition of this genus as given by Greville. By the use of extremely oblique light, and the homogeneous immersion objective of Zeiss, I have been able to recognise that the long elevated areas project horizontally from their origin, and separate afterwards like the talons of a bird of prey—an observation which has suggested the specific name that has been applied to this interesting form.

Eupodiscus, Ehrenb.

While Pritchard, in his History of Infusoria (p. 842), notifies the characteristics of this genus, which is especially distinguished by the processes disposed around its valves, he very justly observes that the genus *Actinocyclus* of Ehrenberg is probably identical with *Eupodiscus*, and that therefore it is wrong to ascribe the former to the *Coscinodisci*. The only notable difference between *Actinocyclus* and *Eupodiscus* consists in the number of the pseudo-noduli or submarginal processes, of which only one occurs in the former, while two or more are to be found in the latter.

In the Challenger Collection *Eupodiscus jonesianus*, Grev., is pretty frequent, having been collected in several localities, such as the Sea of Japan, at Hong-Kong, in the Arafura Sea, in the Southern Ocean between Kerguelen and Heard Islands, and elsewhere. At first, however, it is difficult to determine this Diatom specifically. Notwithstanding the well-known facility which Greville possessed of drawing the most delicate and elegant diatomaceous frustules, his figure of this species does not agree sufficiently exactly with its natural appearance. This will be at once admitted when a comparison is made between plate ii. fig. 3 of the Transactions of the Microscopical Society of London, vol. x., new series, 1862, and the description which Greville himself gives at page 22 of the same volume. This description, however, perfectly coincides with the valves collected by the Challenger, but it is necessary to remark that among the many specimens in my possession not one is furnished with more than two submarginal processes, while these are disposed as if the periphery were tripartite, the place of the third process remaining vacant.

Eupodiscus insutus, n. sp. (Plate XIX. fig. 6.)

Disciformis; tribus processibus submarginalibus munitus; valvis areolatis et radianter punctulatis; areolis grandiusculis, subrotundis, rariusculis. In Oceano Atlantico meridionali.

This superb Diatom, from the South Atlantic, has a diameter of 186 μ. Although at first sight it seems to be identical with *Eupodiscus argus*, Ehrenb.,[1] I found, on comparing it with the type of that species shown in the Typenplatten of Möller, and with other specimens in my possession, that it could not be confounded with the latter. Thus the figure here given—which is correct in every way except that the punctation of the margin is somewhat larger and thicker in the original, a character which could not be exactly drawn without confusing the areolæ—shows that these areolæ are never stellate, but irregularly circular. The three submarginal processes divide the perimeter of the valve irregularly. The double structure, consisting of areolæ and granules, observable in the valve, as well as in that of *Eupodiscus argus*—a peculiarity which is also met with in the species of other genera—seems to point to the existence in the cell walls of two strata, of which one may sometimes become detached from the other, as if the more finely granulated layer served as a lining for the other.

Actinoptychus, Ehrenb.

This genus was instituted by Ehrenberg in 1838, and was defined as follows:[2]—"Frustules disciform, cellulose, disc divided into equal triangular compartments by lines or internal septa."

The term *septa* here employed is unfortunate, as it is used for those lines of division which, in an almost diaphragm-like manner, cross the lumen of the diatomaceous cell, *e.g.*, in *Striatella*, *Rhabdonema*, &c.; but in the present genus the lines of division are but indications of the alternate depression and elevation of the compartments, and are not *septa* in the usual sense.

Although the general aspect of the genus *Actinoptychus* is similar to that of *Omphalopelta* (Ehrenb.), Cstr., the latter is readily distinguished by the possession, in each of the triangular compartments, of an intramarginal denticule or spine.

Smith, in his Synopsis of the British Diatomaceæ, has, on the other hand, confounded the genus *Actinoptychus* with that of *Actinocyclus*—an error which resulted from his having regarded as an *Actinocyclus* a species which was wrongly classed in this genus by Kützing, instead of being grouped with the species of *Actinoptychus*.

Actinoptychus raëanus, n. sp. (Plate VII. fig. 4.)

Forma rotunda, granulata, cellulosa; sex dissepimentis triangularibus distincta, cellulis (areolis) subquadratis, denticuli grandiusculi plures intramarginales irregulariter distributi; umbilicus definitus hyalinus. Fossilis in deposito S$^{\text{tæ}}$ Monicæ in California.

Among the excellent preparations of Diatoms made from the Challenger collections by

[1] Smith, Synop. Brit. Diat., vol. i. p. 24, pl. iv. fig. 39; Rabenhorst, Flora Europæa Algarum, sect. i. p. 319, &c.

[2] Pritchard, *op. cit.*, p. 839. Various species of this genus are figured in Ehrenberg's Mikrogeologie.

Dr James Rae, R.N., and kindly placed at my disposal in connection with my present work, I found this singular frustule, which, although brought from the interesting and rich deposits of St Monica in California, I have deemed worthy of being figured in order to convey a clear idea of its remarkable structure. The large disc possesses six compartments, and the valve is delicately granulated in a quincuncial manner. The large cellules or areolæ possess a subquadrate form—a character which is not represented in any other type. At the margin numerous large denticules occur; these are irregularly distributed, and project from the inner part of the margin so as to cause the frustule to assume the appearance of an irregularly toothed wheel.

The specific name which has been given is in honour of its discoverer, Dr James Rae.

Actinoptychus erosus, n. sp. (Plate VII. fig. 8.)

Frustulum disciforme in decem septa a tot lineis lævibus divisum, et decussatim granulatum; granulis prope marginem et alibi quandoque cessantibus; area centrali hyalina rotunda. In Atlantico meridionali.

This form, which was collected in the South Atlantic, is divided into ten compartments by ten smooth lines which do not quite reach the centre, this being occupied by an umbilical hyaline area. The compartments are granulated in a quincuncial manner, except in some small irregular spots, which are smooth, as if the valve had been eroded at the places in question. The margin consists of a smooth narrow belt.

The eroded-like aspect of the compartments has suggested the specific name.

Omphalopelta (Ehrenb.), Cstr.

Much confusion has hitherto existed in connection with the genera *Actinoptychus* and *Omphalopelta*, both of which were instituted by Ehrenberg. The definition of the latter genus, as given by Pritchard in his History of the Infusoria (p. 841), is as follows:—"Frustules simple, disciform; disc cellulose or punctate, divided by imperfect septa into cuneate rays; centre hyaline; spines one to each compartment."

Among the four species given by Pritchard under this genus, *Omphalopelta cellulosa*, Ehrenb., and *Omphalopelta areolata*, Ehrenb.,[1] have marginal spines in three of the alternate compartments, while *Omphalopelta punctata*, Ehrenb., is said to have obsolete spines. But it is difficult to understand how forms possessing such a structure can be ascribed to this genus. With respect to the so-called *Omphalopelta punctata*, Ehrenb., there can be no doubt that it should rather be designated *Actinoptychus punctatus*, as it coincides with all the requirements of that genus, while in the case of the other two above-mentioned species, either the original definition given by Ehrenberg must be modified, or they must be enrolled in a new genus.

[1] Ehrenberg, Mikrogeol., pl. xxxv. A 18, fig. 12. = *Actinocyclus areolatus*, Brightwell, *Micr. Journ.*, vol. viii. p. 93, pl. v. figs. 1*a* and 1*b*.

This inconsistency has not escaped the observation of Professor H. L. Smith, who, in his synopsis of the families and genera of Diatoms, which is given in Dr van Heurck's work, entitled, Le microscope, sa construction, son maniement et son application à l'anatomie végétale et aux Diatomées, modified the definition of the genus *Actinoptychus*, Ehrenb., as follows:—"Valves with marginal spines obsolete; or if present, few, and in alternate compartments."

In the family of the *Heliopelteæ* he also gives the genus *Halionyx*, Ehrenb.,[1] to which he attributes the following characteristics: — "Valves with a hyaline (stellate) umbilicus, with marginal spines or teeth connected by a radial rib." But these characters are precisely those of the genus *Omphalopelta*—a genus which Professor H. L. Smith regards as synonymous with *Actinoptychus*, which accordingly possesses spines in alternate compartments, or in each compartment—a circumstance overlooked by Professor Smith. Hence it is preferable to leave the genus *Actinoptychus* intact, and to modify Ehrenberg's definition of *Omphalopelta*, limiting the principal characteristic to the marginal spines, whether they occur in each compartment, or in alternate compartments. Moreover, the number of spines should be limited in number, in order to avoid confusion between *Omphalopelta* and *Heliopelta*, Ehrenb., because in this last group the numerous spines, in addition to its other characteristic marks, do not, when carefully examined, present the appearance of spines, but of small spheroidal processes.

The genus *Omphalopelta* may accordingly be defined as follows:—Frustulum simplex, discoidale; valvis cellulosis vel punctatis, in cuneatis dissepimentis distinctis; area umbilicali hyalina; spinis marginalibus in omnibus vel in alternis dissepimentis."

Omphalopelta antarctica, n. sp. (Plate VII. fig. 2.)

Valvis areolato-punctatis, in sex partes alternatim elevatas et depressas distinctis; area umbilicali parva, hyalina, indefinita; denticulo in elevatioribus dissepimentis submarginali; lato margine irregulari punctulorum corona distincto. Ad mare Antarcticum.

This small disc, which was collected in the Antarctic Ocean, has six alternately elevated and depressed compartments. The valve is delicately punctated in a quincuncial manner, and also possesses distinct rounded cellules or areolæ. The hyaline centre is small and not distinctly defined, while a single intramarginal denticule occurs in each of the three elevated segments, but is absent from the depressed segments. The margin is for the most part smooth, but it is distinguished externally by an irregular circle of small points. The occurrence of this circle of puncta, as well as of the rounded areolæ, is especially noteworthy.

Omphalopelta japonica, n. sp. (Plate VII. fig. 10.)

Areolato-punctata; area umbilicali indefinita; dissepimentis pluribus (18) elevatis et depressis, et denticulo marginali distinctis. In mari Japonico.

[1] Ehrenberg, Mikrogeol., pl. xxxv. A 21, fig. 12.

In Pritchard's History of the Infusoria (p. 841), we read:—"All the species of *Omphalopelta* resemble *Actinoptychus senarius*," and indeed all the specific forms there recorded have six compartments and the characteristic submarginal spines. The Diatom now in question, however, forms a beautiful disc, with eighteen compartments, each of which is furnished with a distinct denticule or spine. As in all the species of *Omphalopelta*, the segments are alternately elevated and depressed, while the centre is occupied by a smooth ill-defined area. The axis of each segment is marked by a radial line, which extends from the central area and disappears soon after reaching the middle of the compartment. At the circumference, and at the middle of the outer margin of each compartment, there is an evident denticule which is of the utmost importance for the generic determination. The valve is ornamented with small decussately disposed granules, while traces of areolation are found here and there.

The frustule presents a great resemblance to a Diatom found abundantly by Shadbolt[1] in guano from Callao, as well as in the Port Natal gathering, upon which that observer instituted the genus *Actinophœnia*, and which he named *Actinophœnia splendens*. It is hard to understand the reason which induced Pritchard[2] to class this form with the genus *Actinoptychus*, since he described it as possessing a denticule or spine in each compartment, and so should have named it *Omphalopelta splendens*. On comparing, however, the description with our present figure, it may be observed that in Shadbolt's species the umbilical hyaline area, instead of being indefinite, is well defined. It is further to be noted, on consulting the figures of *Actinophœnia splendens* given by Roper,[3] that the denticules correspond to the point of division between two compartments. Thus in Pritchard's supposed *Actinoptychus*, the segments would not be alternate in the ordinary sense, we should rather have to regard the number of the compartments as being double what is stated, and to look upon the denticules not as placed at the middle of the segments but as marking the extremities of the divisional lines. Moreover, in our present frustule, the number of denticules is greater than in that of Shadbolt, and the vertices of the elevated segments are narrower than those of the depressed segments. Finally, Shadbolt's species is destitute of the striated margin seen in the present case. From such considerations the specific value of the present form from the Sea of Japan can hardly be questioned.

Omphalopelta (?), sp. (?) (Plate XVI. fig. 8.)

This small irregular disc is probably a monstrous form of some species of *Omphalopelta*. The cuneate septa are almost invisible, while the outline of the valve is entirely anomalous. Like other species of this genus, however, it possesses a hyaline umbilical

[1] See a note entitled A defence of the proposed new genus *Actinophœnia*, Shadb., in *Micr. Journ.*, vol. ii. pp. 201–203; Edwards on Diatomaceæ collected in the United States, *Micr. Journ.*, vol. vii. 1859, p. 88.

[2] Pritchard, *op. cit.*, p. 840.

[3] Roper on the Diatomaceæ of the Thames, *Micr. Journ.*, vol. ii. pp. 73, 74, pl. vi. fig. 2.

area of indefinite outline and submarginal spines, one of which occurs in the middle of each fasciculus. The granulation is fasciculate—a circumstance which prevents me from determining the genus to which the frustule belongs, as other species belonging to this group and possessing a similar condition of striation are unknown to me. Should similar forms be recorded in future, they must be regarded as normal, and not as teratological, or should a species of *Omphalopelta* be discovered with fasciculate striation, the present specimen may probably be attributable to that species.

Omphalopelta parda, n. sp. (Plate XVIII. fig. 9.)

Forma magna, rotunda, in sexdecim dissepimentis alterne elevatis et depressis divisa; margine striato et granulorum corona cincto; dissepimentis depressis brevi radio ad verticem instructis, elevatis; denticulo in media basi; superficies celluloso punctata; area umbilicalis indefinita. In mari Pacifico.

This superb discoidal Diatom was procured from mud, which was brought up from a depth of 1875 fathoms near Japan. The disc is bounded by a well-defined striated border, which is provided on its inner side with a corona of granules. Interiorly it is divided into sixteen cuneiform compartments, which start from a smooth central area, with indefinite outline. These compartments are alternately elevated and depressed, the latter appearing flat, while the former are longitudinally ridged in a roof-like manner. Each of the depressed segments is marked at its vertex by a radial line which soon vanishes, while each of the elevated areas bear a denticule near the margin, and at the middle of the basal side; this denticule is united to the central area by means of a narrow linear space. The valve is punctated in a decussate manner, and presents ill-defined traces of arcolation, especially in the elevated compartments. Each of the depressed segments presents a remarkable smooth broadly linear area at its base: in this no trace of striation could be determined.

According to the amended definition which has been given above, this very attractive Diatom must be classed in the genus *Omphalopelta*; but, apart from this emendation, it should be ascribed to that of *Actinoptychus*, Ehrenb.

Omphalopelta shrubsoliana, n. sp. (Plate XXIII. fig. 2.)

In sex dissepimentis alternis triangularibus distinctum; area umbilicali hyalina subhexagonali; dissepimentis decussatim granulatis, alterne inermibus et spina a margine dissita instructis. Dissepimenta medio turgescunt. Ad Zebu.

This disc was collected in the Channel of Zebu, among the Philippine Islands. It is divided into six triangular segments, of which the alternate ones are similar to each other. These compartments are granulated in a quincuncial manner, and are slightly swollen at the centre. Each of the three alternate segments whose apices are transversely truncated

bear at their base, and at a considerable distance from the margin, a denticule which serves to distinguish the present Diatom from other species. The apices of the non-denticulated compartments are rounded, so that a central hyaline hexagonal area results, which is circumscribed by straight and concave sides. The margin of the valve is convex.

The specific name has been given in honour of Mr Shrubsole, who is well known for his researches on the fossil Diatoms of the Lower Eocene of the London basin.

Asteromphalus, Ehrenb.[1]

This genus essentially consists, like that of *Asterolampra*, Ehrenb.,[2] of an areolated granulated disc, which bears a hyaline star and umbilical lines of division. It differs, however, from the latter in the single important circumstance that one of the radial areas is so much narrower than the others as to be almost obliterated. The umbilical lines and the form of the granulated segments constitute the principal distinctive characteristics between the specific types. The genus, which was established by Ehrenberg, has been defined as follows:—"Frustules simple, disciform; disc as in *Asterolampra*, but with two of the punctated compartments approximate, and the interposed ray narrower than the others."[3]

Marine Diatoms belonging to this group are by no means rare, but the transparency of the valves is such that they are often not perceived in Canada Balsam preparations. Although the genus *Asteromphalus* is richer in species than that of *Asterolampra*, the following new forms belonging to the former have been observed in the Challenger collections:—

Asteromphalus ovatus, n. sp. (Plate V. fig. 7.)

Elliptico-rotundatum; segmentis rotundato-complanatis; lineis umbilicalibus rectis vel non angulariter curvatis, ab area pyriformi dimanantibus; areis radialibus marginem non attingentibus. In mari Antarctico.

This very small oval Diatom, which in the figure is magnified 1000 diameters, is distinguished by the circumstance that the umbilical lines do not separate from one another, as in the others, at a central point, but originate from the circumference of the area of the obliterated radius. This characteristic has been found, it is true, in other allied forms, among which Brébisson constituted the genus *Spatangidium*;[4] but this genus has not

[1] *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1844, p. 198.

[2] See definition in *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1844, p. 73.

[3] Pritchard, *op. cit.*, p. 836.

[4] e.g., *Spatangidium flabellatum*, *Spatangidium peltatum*, *Spatangidium arachne*, *Spatangidium heptactis*, in *Bull. Soc. Linn. de Normand.*, vol. iii.; *Spatangidium ralfsianum*, Norm., Greville on Diatomaceæ observed in Californian Guano, *Micr. Journ.*, vol. vii. p. 161.

been accepted, as it is not sufficiently distinct from that of *Asteromphalus*, to which the forms in question accordingly remained annexed.

Asteromphalus ovatus presents, however, several points of resemblance to the *Asteromphalus shadboltianus* of Greville,[1] who described this latter Diatom as an *Asterolampra*, having endeavoured to join the two genera *Asteromphalus* and *Asterolampra* into one under the latter name, because by supposing one radius of *Asterolampra* to remain undeveloped there would be left no means of distinguishing them. This supposition, however, has failed to meet with the acceptance of other micrographers. The points of difference which may be noted between the frustule now before us and *Asteromphalus shadboltianus*, Grev., are the following: (1.) The form of the umbilical lines which proceed from the superior margin of the pyriform area of the obliterated radius are angularly curved and almost broken in the Grevillian species, while in the present form they are straight, with the exception of those separating the inferior radial areas, which are slightly curved, but by no means bent in a zigzag manner, as in the other case. It is to be remarked, however, that the occurrence of a bending in the umbilical lines is of little significance, because all gradations may be found in the same species, from the most decided curves to simple lines which are but slightly tortuous or may even be straight. (2.) The present form is smaller than the species established by Greville; and (3.) the former, instead of being round like the latter, is oval. From these considerations the specific value of *Asteromphalus ovatus* cannot be questioned.

Asteromphalus roperianus, Grev., var. *atlantica*, nov. (Plate V. fig. 3.)

This frustule also belongs to the group designated *Spatangidium* by Brébisson. It presents a beautiful granulated disc on which a hyaline star with six radii—apart from that which is obsolete—occurs. It is very closely allied to *Asteromphalus roperianus*, Grev.:[2] in both there is the same number of radii, of interradial areas with straight vertices, and the central area of the obsolete radius, at which the other umbilical lines meet, is campanulate in both. It differs from Greville's species, however, in the following respects: (1.) The extremities of its radial areas are slightly expanded, and terminate some distance from the margin of the frustule. (2.) The granulated segments at the apices terminate abruptly and not in a somewhat undulating manner, as in the figure given by Greville, who represents two slightly convex curves as starting from the two angles of the apex and meeting in a slight involution at the intermediate umbilical line. Notwithstanding these points of difference, however, the present frustule can only be regarded as a variety of Greville's species, and it has been named *atlantica* from the locality in which it was found.

[1] A monograph on the genus *Asterolampra*, including *Asteromphalus* and *Spatangidium*, by R. K. Greville in *Micr. Journ.*, vol. viii. p. 121, pl. iv. fig. 19, 1860.

[2] *Micr. Journ.*, vol. viii. pl. iv. fig. 14, 1860.

Asteromphalus challengerensis, n. sp. (Plate V. fig. 2.)

Forma rotunda; lineis umbilicalibus tribus a centro dimanantibus, hinc bipartitis vel tripartitis; lineæ umbilicales rectæ; segmentorum vertices obtuso-rotundati; area radii obsoleti fere obliterata. In mari glaciali Antarctico.

This round Diatom bears a star with eight radii apart from the obsolete radius. The umbilical lines are three in number, start from the central point, and afterwards subdivide. The vertices of the segments are obtusely rounded, and the central area of the obliterated radius has vanished.

Asteromphalus challengerensis (?), n. sp. (Plate IX. fig. 2.)

Forma monstrosa. In mari glaciali Antarctico.

The frustule here represented is exceedingly instructive and interesting. It is evidently a monstrous form, and doubtless originates from the coalescence and simultaneous development of two germs which have combined to form a single frustule. Although similar teratological phenomena frequently occur in the fruits of phanerogams, I have not met with an example hitherto among Diatoms, nor am I aware of its having been observed by others. Although the precise specific determination of such an abnormality is a matter of considerable difficulty, no doubt can exist as to the generic name, inasmuch as an obsolete radius is present, and at once determines it to be an *Asteromphalus*. Moreover, from the rounded form of the granulated segments, the linear outlines of the radial areas, the locality in which it was procured, and its association with other frustules of the same genus, it can hardly be doubted that we have here to deal with a specimen of *Asteromphalus challengerensis*.

It is to be noted that, while we are here brought face to face with the development of a double germ or double sporule, the two germs, though the products of the same parent, possess different characters, so that the one would apparently have given rise to a frustule with a smaller number of radii than the other. If this be admitted, then it is clear that no importance should be placed on the number of radii in specific determinations.

Asteromphalus wyvillii, n. sp. (Plate V. fig. 6.)

E maximis; radiis præter obsoletum viginti sex, intra marginem terminantibus denticulo signatis; areæ granulatæ intramarginales ad verticem truncatæ; lineæ umbilicales ab area radii medii circumradiantes, simplices vel semel et bis dichotomæ, et medio dupliciter curvatæ. Diametrum areæ centralis 65 μ, valvæ 226 μ. In mari Pacifico.

This is without doubt the most singular and superb specimen of the genus *Asteromphalus* which has up till now been recorded. Its immense size (= 226 μ in diameter), the great number of its radii, and the relative smallness of the central disc of the star are remarkable. From the outline of the central area of the obsolete radius proceed many

of the umbilical lines of the twenty-six remaining radii, and among these some remain simple, while others bifurcate once or twice. Almost all the lines have a double curve in the course of their length, and the hyaline radii terminate before arriving at the circumference in a salient or denticulate point. The apices of the granulated segments are sharply truncated.

The specific name of this elegant frustule has been given in honour of the late Professor Sir Wyville Thomson, formerly Director of the Challenger Commission.

Asteromphalus antarcticus, n. sp. (Plate XVI. fig. 11.)

Forma rotunda, parva; dissepimentis cuneatis, ad verticem truncatis; lineis umbilicalibus rectis; areis radialibus linearibus et denticulo terminali instructis. Ad mare Antarcticum.

This small disc was collected by means of a surface net to the south of Heard Island in the Antarctic Ocean, being found associated with many specimens of *Asteromphalus darwinii*, Grev.[1] It possesses five radii — apart from the obsolete radius — and the umbilical lines are straight and proceed from the centre. The radial areas are broadly linear, and each terminates near the margin in a well-defined granule. The areolated segments are bounded by internally concave margins, with the exception of those which flank the obsolete radius, and which pass by an elegant curve into the smooth area in the centre of the disc. The *ensemble* of such characters must be looked upon as sufficient to constitute a good species.

Asterolampra, Ehrenb.

The genus *Asterolampra*, though bearing a great affinity to certain forms of *Asteromphalus*,[2] has been too hastily united with the latter by Greville.[3] It embraces some of the most elegant forms of Diatoms, and has been defined by Ehrenberg, as noted by Pritchard (*op. cit.*, p. 836), in the following manner:—"Frustules simple, disciform; disc orbicular with marginal areolated or punctated compartments, separated by smooth rays which proceed from a hyaline central area; central area divided by lines which radiate from the umbilicus to the apex of each compartment, compartments and rays symmetrical." The

[1] *Micr. Journ.*, vol. viii. pl. iv. figs. 12 and 13.

[2] This genus was established by Ehrenberg for certain Antarctic Diatoms brought home by Sir Joseph Hooker, and collected during the cruise of H.M.SS. "Erebus" and "Terror," *Monatsber. d. k. Akad. d. Wiss. Berlin*, 1844, p. 198. See also Kützing, *Spec. Alg.*, 1849; *Amer. Journ. Sci. and Art.*, vol. xxii. p. 1; Ehrenberg, Mikrogeologie, pl. xxxv. A closely allied genus, *Spatangidium*, was proposed by Brébisson in 1857, *Bull. de la Soc. Linn. de Normand.*, vol. ii.

[3] Greville, Descriptions of Diatoms observed in Californian Guano, *Micr. Journ.*, vol. vii. p. 157; Greville on the Asterolampræ of the Barbados Deposit, *Micr. Journ.*, n. s., vol. ii. p. 42; Wallich on Siliceous Organisms found in the Digestive Cavities of the Salpæ, and their relation to the Flint Nodules of the Chalk Formation, *Micr. Journ.*, vol. viii. p. 44.

rays of the hyaline star are all equal to one another, and the lines which radiate from the umbilicus are well defined on the circular granulated area. Though several specimens of this genus have been observed, none present any very well-marked characteristics.

Asterolampra grevillii, (Wall.) Grev., var. *eximia*, nov. (Plate V. fig. 5.)

This magnificent disc was procured from soundings taken at the equator in the Atlantic Ocean. It is 175 μ in diameter, and although it does not agree in all its features with any species hitherto recorded, it approaches most closely to *Asterolampra grevillii*, (Wall.) Grev., which has been defined by Greville[1] in the following terms :—"Areolated segments square at the base; rays numerous; umbilical lines divided and arranged in parcels or groups of from two to five lines each." In this description it is to be remarked that the term *base* ought rather to be *apex*, as it has reference to the smaller extremity of a pyramidally shaped area, while the word *square*, though applying exactly to the frustule now in question, should be replaced by the designation *subquadrate*, as may be at once observed on consulting the figures given by Greville and Wallich.

The following additional points of distinction between *Asterolampra grevillii* and the Challenger frustule, may also be pointed out :—(1.) The umbilical lines in the former are, as above indicated, in groups of from two to five, but in the latter of from three to seven; (2.) The number of rays in the former are from thirteen to seventeen, while in the latter they are twenty; and (3.) the radius of the central disc of the former exceeds one-third of that of the entire valve, while it is less than a third in the latter.

All these distinctions, however, can hardly be regarded as of sufficient importance to justify the establishment of a new species for the frustule now figured for the first time, but the elegance of its ornamentation has suggested the varietal name *eximia* which has been selected.

Asterolampra decora, Grev., var. nov. (Plate XVI. fig. 9.)

The frustule here shown bears a strict analogy to the *Asterolampra decora* of Greville. The designation *punctiform*, however, which has been applied to the latter,[2] cannot be given to the cellules of the present specimen, which possesses nineteen rays instead of the variable number—five to fourteen—recorded by Greville in the course of his examination of twenty-five specimens of the typical species. Such distinctions seem to indicate clearly the varietal character of the present Diatom.

Heterodictyon, Grev.

Greville established the genus *Heterodictyon* in the year 1863, in his interesting paper on new and rare Diatoms published in the Transactions of the Microscopical Society of

[1] *Micr. Journ.*, vol. viii. p. 113, pl. iv. fig. 21 = *Asteromphalus grevillii*, Wall., *Micr. Journ.*, vol. viii. p. 47, pl. ii. fig. 15.

[2] *Micr. Journ.*, n. s., vol. ii. p. 45, pl. vii. figs. 4–6.

London, new series, vol. ix. p. 66, and defined it in the following manner:—"Frustules free, disciform; disc with radiate or scattered cellules or puncta in the middle portion, and a circle of large intramarginal cellules." The genus has hitherto comprised only the two species *Heterodictyon rylandsianum*, Grev., and *Heterodictyon splendidum*, Grev., both of which were found by Greville [1] in the Barbados deposit, Cambridge, U.S.A.; but I am of opinion that the former, on account of the corona of large linear or oblong cellules with which it is provided, should be ascribed to the genus *Asterolampra*, and named *Asterolampra vulgaris*, Grev.,[2] which is from the very same deposit, and of which other six different forms have been given.

Heterodictyon jeffreysianum, n. sp. (Plate XXI. fig. 8.)

Disciforme; medio inordinate cellulosum; subtriangularium areolarum corona submarginali; spatiis intramarginalibus cellulis decrescentibus obsitis. Ad insulas Philippinas.

This new species was collected in the neighbourhood of the Philippine Islands. Though its elegant form might at first sight be mistaken for that of *Asterolampra marginata*, Grev.,[3] it may be readily distinguished from the latter, in which the central part is covered with puncta disposed in radiating lines, by having the sculpturing arranged without order. The corona of large cellules on the submarginal area is composed of subtriangular compartments, two of the angles being blunted at the points of contact with adjoining compartments. The cellules in the intramarginal segments, circumscribed by the submarginal belt, diminish towards the periphery.

The specific name has been given in honour of the well-known English naturalist, Dr Gwyn Jeffreys.

Brightwellia, Ralfs.

This genus was established by Ralfs in honour of the well-known microscopist, Brightwell. The Diatom, which the latter observer had named *Craspedodiscus coronatus*,[4] was found to differ from the other members of that genus by the possession of a corona of oblong cellules, which separated the central from the peripheral part of the disc, and Ralfs,[5] who first drew attention to this important circumstance, ascribed the frustule to his new

[1] *Micr. Journ.*, n. s., vol. iii. p. 66, pl. iv. figs. 6 and 7.

[2] *Micr. Journ.*, n. s., vol. ii. p. 47, pl. vii. figs. 17–22.

[3] *Micr. Journ.*, n. s., vol. ii. p. 50, pl. viii. fig. 30.

[4] Brightwell on some of the Rarer or Undescribed Species of Diatomaceæ, *Micr. Journ.*, vol. viii. p. 95, pl. v. fig. 6.

[5] Pritchard, *op. cit.*, p. 940. "This species is very variable in size. In a dry state it is of a purplish or brown colour, but in balsam hyaline; the centre has the granules irregular near the umbilicus, and interrupted by blank rays; but near the circlet of cellules they become more regular, and form curved, moniliform lines. The broad limb is usually brownish when dry, and marked by numerous radiating lines similar to those of *Coscinodiscus concinnus*, and have in the intervals extremely minute obliquely arranged granules. The radiating lines, although conspicuous in the dry state, nearly disappear in balsam."

genus, which he defined as being a disc with a large granulated centre, separated from a broad punctated limb by a circle of oblong cellules.

Among the Diatoms collected by the Challenger, a beautiful specimen of this genus has been found, but it does not exactly agree with all the characteristics indicated in the definition given by Ralfs. The disc is notably convex, and there is a central round space, covered with beautiful granules, which decrease in size as they approach the centre, and are at the same time disposed in excentric curves. Similar characteristics are to be found in *Brightwellia elaborata*, Grev.,[1] and *Brightwellia johnsoni*, Ralfs, MS.; but the *markedly round* form of the large cellules, which constitute the corona and divide the central from the outer part of the valve, readily differentiate our new frustule. The generic definition may accordingly be modified in the following manner:—Frustulum disciforme præstans partem centralem cellulosam a reliqua superficie punctulata vel granulata per coronam majorum cellularum divisam.

Brightwellia murrayi, n. sp. (Plate X. fig. 2.)

Forma rotunda, convexa; centro cellulis decrescentibus in lineas excentricas et concavas dispositas insigni; a lato margine radiatim granulato per coronam grandiuscularum rotundarum cellularum distincta.

This elegant disc is notably convex, and possesses a broad margin, which is covered with thickly disposed equal radiating rows of granules of medium size. The large central area is elegantly ornamented by pearl-like granules arranged in excentric curves, and decreasing in size as they approach the centre. The central part of the valve is separated from the peripheral by a corona of large round cellules, which serve to render the contrast between the two portions more conspicuous.

The specific name has been given in honour of Mr John Murray, the present Director of the Challenger Commission.

Porodiscus, Grev.

This genus is akin to that of *Coscinodiscus*, and was instituted by Greville[2] to embrace forms which agreed with the following definition:—"Frustules free, disciform, composed of two discs united by an intermediate ring-like zone; discs very convex, minutely radiato-cellulate or punctate, with a conspicuous central pseudo-opening or pore." No specimen of this interesting genus has hitherto been discovered, save in the well-known Barbados deposit in the United States of America; and it is therefore of the greatest importance that the frustule now to be recorded should have been found by the Challenger in a sounding made at the equator, as it goes to justify the belief that many, if not all,

[1] Greville, Descriptions of New and Rare Diatoms, *Micr. Journ.*, n. s., vol. i. p. 73, pl. ix. fig. 1.
[2] *Micr. Journ.*, n. s., vol. iii. p. 63.

of the forms at present only known as occurring in geological deposits may ultimately be discovered in the living condition in the ocean.

Porodiscus stolterfothii, n. sp. (Plate XII. fig. 8.)

Forma rhombico-elliptica; pseudo-ostiolo subrotundo mediocri; striis radiantibus stipatis. In Oceano Pacifico.

This very singular Diatom at first sight recalls the *Porodiscus oblongus* of Greville,[1] which has been characterised as being an elliptico-oblong disc with a large pseudo-opening; this, by reference to the figure, being found to be equal to one-third of the transverse axis and perfectly round. In the present case, however, the form of the valve is rhomboido-elliptical, and the pseudo-opening is much smaller and somewhat oval, while the radiating lines of granules are much more crowded than in the Grevillean species.

The association of these differences must be regarded as sufficient to constitute a new species, which has been named in honour of the English Diatomist Dr H. Stolterfoth, who has rendered much valuable aid in connection with the present work.

Hyalodiscus, Ehrenb.

The genus *Hyalodiscus* has been defined by Pritchard (History of the Infusoria, p. 814) in the following terms :—"Frustules simple, disciform; disc smooth, flat, its umbilical portion or centre separated by a distinct suture;" and he points out that it differs from the genus *Podosira*, Ehrenb., in having a flat disc. I am, however, inclined to adopt the view of Professor H. L. Smith, who thinks it very probable that the *Hyalodisci* are only valves of *Podosira*—a genus which he unites to that of *Melosira*, Ag. But on the other hand, although *Podosira* has never yet been met with in long series of many frustules, it seems to be desirable to retain it as a genus distinct from that of *Melosira*, as we thereby retain a distinction between two kindred series of forms.

It may here be observed, on the other hand, that it is by no means easy to understand how O'Meara described and figured,[2] under the name of *Pyxidicula radiata*, a form collected by Mr Moseley at Kerguelen Island, as no *Pyxidicula* presents an umbilical area which is separated by a line of suture from the rest of the surface of the valve. O'Meara ought rather to have named his specimen *Podosira* (or *Melosira*) *radiata*, as the form of the valve, which is the only common character between his Diatom and the genus *Pyxidicula*, is equally common to the two genera just named.

Hyalodiscus (Pyxidicula, O'Me.), **radiatus**, var. nov. (Plate X. fig. 1.)

A kindred, if not identical, frustule to that described and figured by O'Meara is here represented. The disc has its surface divided into three well-defined zones, the wide

[1] *Micr. Journ.*, n. s., vol. iii. p. 65, pl. iv. fig. 5.

[2] See Note on the Diatomaceous Gatherings made at Kerguelen's Land by H. N. Moseley, *Journ. Linn. Soc. Lond.* (Botany), vol. xv. plate i. fig. 9.

central area which occupies about two-thirds of the diameter being rugged rather than granulated. The intermediate zone has very fine radiating striæ, while the external circle is ornamented by regularly disposed granules arranged in a quincuncial manner. In this form, as well as in that described by O'Meara, dark lines of variable length radiate outwards from the perimeter of the central zone; these, however, are not "alternately arranged," as referred to by O'Meara, but are distributed irregularly. Moreover, here the margin, instead of being "finely striated," is granulated in a quincuncial manner, each granule being distinctly defined with a magnifying power amounting to only 460 diameters. The additional circumstance, which is well seen in the present frustule, but is not referred to by O'Meara, that the edge is marked by long, irregularly disposed dark lines of variable thickness, is noteworthy. Although both Diatoms were collected in the Antarctic Ocean, they were procured in localities separated by upwards of 40° of longitude; yet the distinctions which have been pointed out cannot be looked upon as sufficient to justify the establishment of two distinct species for the two interesting organisms.

Hyalodiscus subtilis, Bail. var. *japonica*, nov. (Plate XVIII. fig. 4.)

The specimen here shown was collected on the coast of the Sea of Japan. It agrees generally with *Hyalodiscus subtilis*, Bail.,[1] in the size of the umbilical area, in the guilloché-like disposal of the granules, and in the character of the line of suture which limits the central area. This line, however, in the present case is somewhat more indented, while the granules are not difficult to detect and the margin is notably wider—characteristics which are of sufficient importance to justify us in regarding this frustule as a variety of Bailey's typical species.

The fragment shown in Plate XXIV. fig. 4 probably belongs to the *Hyalodiscus lævis* of Ehrenberg.[2]

Cyclotella, Kg.

The genus *Cyclotella*, which was instituted by Kützing, differs but slightly from that of *Melosira*—the frustules of the latter forming longitudinal series, while those of the former occur singly or at most united in pairs. Though *Cyclotella* may thus be regarded as but another form of the genus *Melosira*, the retention of the former generic name is desirable, as tending to prevent confusion, and to facilitate the record of so many distinct types. Of the genus *Cyclotella* an excellent monograph has been prepared by the well-known micrographer Dr Albert Grunow, and his work has been incorporated in the Synopsis des Diatomées de Belgique of Dr van Heurck.

[1] Pritchard, *op. cit.*, p. 815, pl. v. fig. 60.

[2] Ehrenberg, Mikrogeologie, pl. xxxiii. 15, fig. 17; = *Cyclotella lævis*, Kg., and allied to *Cyclotella physoplea*, Pritchard, *op. cit.*, p. 814.

Cyclotella fimbriata, n. sp. (Plate XVII. fig. 16.)

Valvis discoidalibus; area grandiuscula umbilicali bullato-rugosa, a qua striæ dense radiantur, ad marginem fimbriam simulantes. In Oceano Pacifico.

This Diatom was found in a sounding made in the Pacific Ocean at lat. 35° 41′ N., and long. 157° 42′ E., at a depth of 2300 fathoms. It is a small but elegant little disc, adorned with very delicate radiating striæ which diverge from the perimeter of a large umbilical arch, which is rugged rather than granulated. The radiating striæ form, near the margin, a series of very small arches or elegant fimbriæ—a circumstance which has suggested the specific name of this new and interesting Diatom.

Actinocyclus, Ehrenb.

This genus was established by Ehrenberg and has been defined in the following manner:—"Frustules simple, disciform, disc minutely and densely punctated or cellulose, generally divided by radiating single or double dotted lines and having a small circular hyaline intramarginal pseudo-nodule."

In the review of the genus given by Pritchard in his History of the Infusoria (p. 833), the confusion which has been observed in connection with it is ascribed partly to Kützing, who included a few species of *Actinoptychus*, and partly to Smith, who, in his classic Synopsis of the British Diatomaceæ, named the genus *Eupodiscus*, a circumstance which led both Gregory and Roper into error. The real ground of the confusion introduced by Kützing, however, consisted not so much in the fact of his having embraced some of the *Actinopychi*, as in the circumstance of his having falsified the definition given by Ehrenberg, and in having replaced it by a new and substantially different definition, which ran as follows:—"Actinoptychus: Individua solitaria, libera; lorica bivalvis disciformis cellulosa; cellulæ radiis septisque internis radiantibus pluribus interruptæ."

It is manifest that Ehrenberg regarded the condition of the punctated or cellulose disc with its intramarginal pseudo-nodule as the chief and essential characteristic, inasmuch as he makes use of the word *generally* in speaking of the more or less punctated radiating lines, while Kützing notes merely the "cellulæ radiis pluribus lævibus interruptæ" without making the slightest mention of the pseudo-nodule. It cannot, however, be denied that the pseudo-nodule constitutes a morphological factor of sufficient importance to be of generic significance, so that it is necessary either to regard, like Ehrenberg, that structure as an essential characteristic of the genus *Actinocyclus*, or to institute a new genus to embrace those cellulated discs which only present radiating lines with interruptions. In the latter case such lines should not be the means of detaching such discoidal forms from the genus *Coscinodiscus*, of which Kützing has given the following definition:—"Individua solitaria, libera, lorica bivalvis silicea in latere secundario disciformis cribrata, sepimentis interioribus radiantibus nullis."

Since then the generic designation given originally by Ehrenberg must be looked upon as valid, it may further be noted that Pritchard and Ralfs[1] unite under the designation of *Actinocyclus ehrenbergii* not less than one hundred and sixteen species which Ehrenberg had established by giving special value to the radiating divisional lines, and had named after all the gods of Olympus, after stars, historical celebrities, gems, &c. At the same time the species *Actinocyclus moniliformis*, Ralfs,[2] *Actinocyclus ralfsii*, W. Sm.,[3] *Actinocyclus fulvus*, W. Sm.,[3] and *Actinocyclus crassus*, W. Sm.,[3] are retained, while *Actinocyclus panhelios*, Ehrenb., is regarded as a doubtful species. *Actinocyclus interpunctatus*, Bright.,[4] and *Actinocyclus subtilis*, Greg.,[5] are looked upon as the representatives of a section whose discs are generally coloured and ornamented by radiating series of points, while *Actinocyclus tessellatus*, Roper,[6] is regarded as the single type of a second section embracing cellulated hexagonal discs without radiating lines. The *Actinocyclus interpunctatus*, Bright., however, has no trace of an intramarginal pseudo-nodule, and, therefore, cannot be regarded as belonging to the present genus, while *Actinocyclus tesselatus*, Roper, possesses neither a pseudo-nodule nor any other characteristic which might authorise its ascription to this genus.

Rabenhorst, in his Flora Europæa Algarum Aquæ dulcis et submarinæ, follows the example of Kützing in omitting the important generic character above referred to, but that work must be admitted to be greatly deficient generally in its account of marine Diatoms.

It follows, therefore, that although the presence of a pseudo-nodule is indispensable to the conception of the genus *Actinocyclus*, the radiating lines or points which divide the surface into compartments have a more or less accidental character, while among the specimens collected by H.M.S. Challenger discoidal forms distinctly provided with intramarginal pseudo-nodules have been observed to be either finely and closely or sparsely punctated, to possess discoid surfaces either with or without radiating lines, to exhibit large radiating cells, or finally, to have a marginal pseudo-nodule and a disc minutely and closely but irregularly punctated. Since then the essential conditions which separate one organic form from another must be recorded, and since less essential characteristics become more and more extended as the discovery of new and kindred forms goes on, the original definition given by Ehrenberg may now be modified in the following manner:—Frustula simplicia, disciformia, punctulata vel cellulosa, plerumque nonnulis lineis radiantibus distincta, circulari pseudonodulo intramarginali instructa.

[1] Pritchard, *op. cit.*, p. 834. [2] = *Actinocyclus ternarius*, Ehrenberg, Mikrogeologie, pl. xxii. fig. 9.

[3] = *Eupodiscus ralfsii*, *Eupodiscus fulvus*, and *Eupodiscus crassus* respectively. These forms, according to Smith, probably belong to the genus *Actinocyclus*, Ehrenb., but as he has "limited that genus to frustules with undulated valves," he has found it necessary to place these apart. Their position in *Eupodiscus* he regards, however, as doubtful since "the process in all is rather a pseudo-nodule than a projection from the surface of the valve." Smith, Synop. Brit. Diat., vol. i. p. 24, vol. ii. p. 86.

[4] *Micr. Journ.*, vol. viii. p. 94, pl. vi. fig. 17.

[5] = *Eupodiscus subtilis*, Gregory, Diatoms of the Clyde, p. 29, pl. iii. fig. 50.

[6] = *Eupodiscus tessellatus*, *Micr. Journ.*, vol. vi. p. 19, pl. iii. figs. 1*a* and 1*b*.

Actinocyclus clevei, n. sp. (Plate IV. fig. 6.)

E maximis; dense et decussatim punctulatis; centrum sex cellulis oblongis distinguitur, a quo duplices perspicuorum punctulorum lineæ dimanant, superficiem in partes æquales dividentes; pseudo-nodulo intramarginali grandiusculo. Diametrum 360 μ. In mari interno Japonico.

This disc has a diameter of 360 μ, and the great delicacy of its punctation contrasts distinctly with its unusually large size. A central rosette is constituted by a few large irregular oblong cellules, and from this region numerous double lines of more salient points radiate outwards and terminate at the circumference, while the equal interspaces are ornamented by very minute puncta arranged in a decussate manner. The submarginal pseudo-nodule is rather large, and is somewhat elevated above the surface in a subulate manner. The specimen figured was collected in the Sea of Japan.

The specific name has been given in honour of the well-known diatomist Professor Cleve of Upsala.

Actinocyclus japonicus, n. sp. (Plate IV. fig. 3.)

E maximis; valvis fasciculatim punctulatis; fasciculi punctulati lineis radiantibus dissepti quæ in denticulo desinunt; punctuli circum in zonam decussatim dispositi; pseudonodulum submarginale grandiusculum. Ad oras Japonicas.

This magnificent discoid form is not smaller than *Actinocyclus clevei*, but differs notably from the latter in all its remaining characteristics. The puncta, which are disseminated over the valve, are less delicate and more sparsely disposed, and at the centre there exists a group of small points in the middle of an irregular hyaline area. A series of radiating punctated lines divide the surface of the valve into a number of equal segments, which are sculptured by rows of fasciculated granules that are arranged in quincuncial order near the circumference. The radiating lines terminate in submarginally placed denticules, and the external limiting circlet is ornamented by well-defined striæ. The Diatom was found in the vicinity of the coast of Japan.

Actinocyclus ralfsii, W. Sm., var. *challengerensis,* nov. (Plate XXX. fig. 1.)

The frustule here shown was also collected in the neighbourhood of Japan. Although in the course of engraving the striæ have been somewhat unduly reduced in number, it is manifest that it closely resembles the *Actinocyclus ralfsii* of W. Smith. It may be noted, however, that the marginal denticules are more pronounced than in the latter case, while the system of striæ is fasciculate rather than radiating. Notwithstanding these distinctions, it can only be looked upon as a variety of Smith's species.

Actinocyclus pruinosus, n. sp. (Plate IV. fig. 2.)

Valvis ad marginem dense deinde rarius punctulatis; centrum area hyalina nonnulis punctulis medio signata, a qua plurimæ punctulorum lineæ circum distribuuntur. Diametrum 100 μ. In mari Pacifico.

This very elegant form does not entirely satisfy the generic definition given by Ehrenberg. Thus, although a beautiful round hyaline pseudo-nodule occurs near the circumference, the disc, which is divided into thirty-five distinct segments by salient punctated radii, is but sparsely granulated, while, with the exception of a single fasciculus, the granules are densely disposed near the circumference and around the centre, but become more rare over a moderately wide subcentral or submedian area. The centre consists of an irregular smooth area, in the middle of which a small group of points occurs. The diameter of the valve, which was collected in the Pacific Ocean, is 100 μ.

Actinocyclus fasciculatus, n. sp. (Plate IV. fig. 8.)

Valvis cellulosis per lineas cellularum radiantes divisis; segmenta cellulis fasciculatim dispositis, ad marginem in punctis decussatim distributis transeuntibus, areola umbilicali tribus cellulis medio signatis; pseudonodulum submarginale evidens. Fossilis ad Richmond in Virginia.

The cellulated surface of this form is divided into segments by numerous radiating moniliform lines of equal size and originating from a small central area, the middle of which is occupied by three small cellules. The segments are ornamented by fasciculately disposed cellules of uniform size except in an outer zone, where the margin is provided with very minute granules arranged in a decussate manner. The submarginal pseudo-nodule is well seen. The frustule was found in a fossilised condition at Richmond, Virginia.

The specific name has reference to the fasciculate appearance of the sculpturing of the component segments of the valve.

From the consideration of this and the foregoing species it is manifest that the discoidal granulated form of the valve, combined with the presence of an intramarginal pseudo-nodule, can alone be regarded as absolutely distinctive of the present genus, the character of the granulation varying considerably between divergent extremes.

Actinocyclus fasciculatus, n. sp., var. nov. (Plate IV. fig. 8 *bis*.)

A frustule very similar to that last described is here shown. It differs, however, in its smaller size, and in its locality, having been collected in the Atlantic at lat. 37° 24′ N. and long. 25° 13′ W.

Actinocyclus complanatus, n. sp. (Plate IV. fig. 9.)

Valvæ cellulis fasciculatim medio, prope marginem decussatim ordinatis, hinc in punctulorum lineis transeuntes; ad marginem raræ denticulorum lineæ distribuuntur; pseudonodulum intramarginale evidens. In mari Japonico.

This Diatom, which was collected in the Sea of Japan, corresponds in most of its characters to *Actinocyclus fasciculatus*. Its form is discoidal, and the cellules, which are equally distributed over the entire surface of the valve, are disposed in a fasciculate manner. Its centre, however, is not specially differentiated, and the lines which radiated from that region in *Actinocyclus fasciculatus* are here absent. In this respect, therefore, the frustule does not correspond to the definition of the genus as given by Ehrenberg,[1] but the presence of a well-defined submarginal pseudo-nodule clearly indicates its true generic determination.

The specific name that has been given has reference to the entire absence of salient or other differential characteristics at the centre of the valve.

Actinocyclus umbonatus, n. sp. (Plate IV. fig. 4.)

Valvæ umbonatæ, cellulosæ; cellulæ rarius in centro, reliquum fasciculatim ordinatæ; zona marginalis dense lineata; pseudonodulum submarginale cylindricum lateraliter extensum. In mari Antarctico.

This beautiful discoid umbonate Diatom was procured in the Antarctic Ocean. It presents alternate radiating shades as in *Podosira maculata*, W. Sm.,[2] these being due to the distribution of the cellules in fasciculate parallel lines. Near the margin of the oblique surface of the Diatom a small subulate cylindrical structure projects. This was observed in many cases; it always presented the same appearance, and from its oblique direction it can only be the homologue of the pseudo-nodule, its position in the strongly umbonate valve preventing it from appearing round as in other species of the genus. It is important to note that the pseudo-nodule may assume this remarkable appearance, constituting a well-marked process-like elevation on the surface of the valve.

Actinocyclus oliveranus, O'Me. (Plate IV. fig. 7.)

We have here represented one of the commonest and most characteristic forms that occur in the Antarctic Ocean. It consists of a very small irregularly punctated disc which possesses a pseudo-nodule near its margin. I had named the organism *Actinocyclus antarcticus*, but on comparing Part iv. of the Diatoms, edited by T. P. Cleve and T. D. Möller, the same frustule was repeatedly observed by me in preparation 207 made from a sounding taken between Patagonia and the Sandwich Islands, and it has already been designated *Actinocyclus oliveranus*, by the well-known Irish microscopist,

[1] Pritchard, *op. cit.*, p. 833.

[2] Smith, Synop. Brit. Diat., vol. ii. p. 54, pl. xlix. fig. 328.

O'Meara, in his article on the Diatoms collected at Kerguelen.[1] The name which I have suggested can accordingly only be applied in the event of some important distinctions being ultimately determined between the two types referred to.

Actinocyclus (?) denticulatus, n. sp. (Plate IV. fig. 5.)

Granulis radiatim ordinatis, medio æqualibus, ad marginem minutissimis et stipatis; denticulorum corona submarginali; pseudonodulo minimo margini proximo. In mari Arafura, et fossilis ad Richmond in Virginia.

Great difficulty has been experienced in arriving at the generic determination of the present form. This has arisen from the very minute size of the pseudo-nodule, which could only be recognised after very careful examination, being found, unlike what occurs in other species, in the immediate vicinity of the margin. Yet this peculiarity cannot be regarded as sufficient to regard it as not intramarginal, so that the generic definition is not infringed. It is also to be noted, although not an essential character, that the disc is not divided into equal parts by radiating lines. The granules are of moderate size and arranged in a radiating manner, but they become minute and crowded near the margin. There is a submarginal corona of denticules—a circumstance which has suggested the specific name that has been applied. The organism was found in the Arafura Sea, and it has been observed in a fossilised condition at Richmond, Virginia.

Actinocyclus (?) anceps, n. sp. (Plate IV. fig. 1.)

Valvis granulatis; granuli æquales ad centrum nullo certo ordine, hinc fasciculatim distributi; pseudonodulus minimus et ad marginem attingens. In mari Japonico.

The same difficulties as were encountered in the last case, have recurred here in so far as the determination of the genus is concerned, namely, (1.) the small size of the pseudo-nodule which is placed close to the margin, and (2.) the absence of radiating lines dividing the disc into equal compartments. The granules are of equal size and disposed in a fasciculate manner except in the central area, where they are irregular. This organism was found in the Sea of Japan.

Actinocyclus punctulatus, n. sp. (Plate XVI. fig. 3.)

Punctulorum lineis ab area umbilicali hyalina circum radiantibus, et in strias exeuntibus, nonnullis denticulis distinctioribus ad marginem distributis; pseudonodulo a margine paulisper secedente. Ut supra.

This beautiful Diatom approaches the *Actinocyclus pruinosus*, above described, in

[1] *Journ. Linn. Soc. Lond.* (Botany), vol. xv. No. 82, p. 58, pl. i. fig. 7.

being ornamented with punctiform granules which proceed from a smooth umbilical areola, cover the entire surface of the valve, and towards the circumference assume the appearance of very delicate continuous striæ. But in *Actinocyclus pruinosus* (Plate IV. fig. 2) a number of radiating lines of small points pass to the circumference, and these divide the surface of the valve into a series of segments which are ornamented with puncta more or less crowded, and disposed in an irregular manner. Around the circumference of the present frustule a number of salient denticules also occur, and the pseudonodule is very distinct and removed from the margin.

The specific name that has been applied is intended to recall the peculiar character of the punctation.

This Diatom was, like the preceding, collected in the Sea of Japan.

Actinocyclus pellucidus, n. sp. (Plate XXIX. fig 13.)

Valva vix perspicuo lineolarum circulo cincta, interius detegens coronam signorum duplo rariorum; pseudonodulum submarginale distinctissimum. Ad Japonem in mari interno.

This is without doubt the most singular form among the new species of this genus which were collected by the Challenger. The excessive minuteness and transparency of the valve render it almost invisible, and its discovery is entirely due to the use of a superior homogenous immersion lens by Zeiss. The submarginal pseudo-nodule is distinctly elevated. The margin of the disc is surrounded by very minute striæ, and somewhat nearer the centre a corona of small linear dots which are sparsely, but approximately regularly disseminated, seem to correspond to the extremities of the inconspicuous lines that radiate from the centre. No other ornamentation of any kind could be detected. In a Canada balsam preparation, the delicacy of the details cannot be made out even by the best objective, and it is only by the use of monochromatic illumination that they can be detected with certainty.

The specific name has reference to the transparency of the organism, which was collected in an inland sea at Japan.

Actinocyclus pumilus, n. sp. (Plate XII. fig. 2.)

Forma minima; punctulis minimis et inordinatis; centro et margine nodulis vel denticulis signato, processu marginali. Ad meridiem insulæ Heard in mari Antarctico.

A confused and very delicate granulation ornaments this very minute disc. There is a central nodule, and the margin of the valve is decorated by a number of salient points. There is also present an exceedingly minute but distinct marginal process.

This interesting form, which has been named from its small size, was obtained in the vicinity of Heard Island in the Antarctic Ocean.

Euodia (Bailey), Cstr.

Among the *Anguliferæ*, Pritchard[1] enumerates the genera *Euodia*, Bail., and *Hemidiscus*, Wall. The definition of the latter, as given by Wallich,[2] is as follows:—"Frustule free; valve arcuate, with a marginal nodule; cellulation hexagonal, radiate." Professor H. L. Smith, however, according to Dr van Heurck,[3] speaks of *Hemidiscus* as possessing somewhat different characters, namely, "valves celluleuses, centre blanc, marge veinée."

The genus *Euodia*, Bail., is defined by Pritchard in these words—"Frustules cellulose or granulate, in lateral view lunate;" while Professor H. L. Smith,[4] after describing the *Palmeria* of Greville thus—"Valves with indistinct umbilicus, finely punctate with radiating lines, dorsal and ventral margins with minute teeth or spines"—characterises *Euodia* as follows—"All others, dorsal margin without spines, ventral frequently with a small pseudo-nodule."

Thus in the case of *Euodia* Bailey only requires the lunate form and the cellulose structure of the valve as distinguishing features, while Smith demands that the dorsal margin be devoid of spines and the ventral often provided with a pseudo-nodule. In the case of *Hemidiscus*, on the other hand, Wallich regards an arcuate form, a cellular radiating structure, and a marginal nodule as essential; whereas Professor H. L. Smith[4] insists on "cellular valves, clear centre, and veined margin."

To avoid such confusion, I believe, from the observations which I have been enabled to make, that the two genera, *Hemidiscus* and *Euodia*, should be united into one. This view has also been propounded by Pritchard, who, after defining the *Hemidiscus* of Wallich, adds—"We doubt whether the *Hemidiscus* be distinct from *Euodia*, since the only distinction seems to be the marginal nodule of the former—a character perhaps overlooked by Professor Bailey."

In the marine soundings of the Challenger the lunate forms of *Euodia* and *Hemidiscus* have to be recorded as among the least uncommon forms of Diatoms. They are found of all sizes and in all positions, and they are more or less arcuate in outline, having circular or parabolic curves, the ventral line being almost plain or possessing an inflation in the centre, and being not much less swollen than the dorsal line. I have frequently found specimens with a more or less distinct ventral nodule, but have at the same time observed a few devoid of any such structure. The latter I named *Euodia*, and the former *Hemidiscus;* but on several occasions I had the opportunity of observing some semi-lunate valves in series of two or more frustules, and on examining

[1] Pritchard, *op. cit.*, p. 852.

[2] On the Siliceous Organisms found in the Digestive Cavities of the Salpæ, and their relation to the Flint Nodules of the Chalk Formation, *Micr. Journ.*, vol. viii. p. 42, 1860.

[3] Le Microscope, sa construction, son maniement et son application spècial a l'anatomie vegetale et aux diatomées, par le Dr Henri van Heurck.—Troisième edition, Bruxelles, 1878.

[4] *The Lens*, vol. i. p. 18, 1872.

the different valves the ventral line and margin alternately were found sometimes to be provided with, but sometimes to be devoid of, a nodule; so that in such forms the superior valve has not the marginal nodule which exists in the inferior. This circumstance recalls what takes place in *Cocconeis* and *Achnanthes*, since in the former a central nodule, and in the latter a stauros, is to be found only on the inferior valve.

Since, then, the genus *Euodia*, Bail., was instituted prior to that of *Hemidiscus*, Wall., the name of the united genera must be *Euodia*, Bail., and its definition may be amended as follows:—Frustulum cellulosum vel granulatum; valvis lunatis; nodulo ventrali marginali in inferiori valva.

I have already had the opportunity of observing similar lunate valves while preparing a report on a sounding made in the Atlantic by the "Porcupine" in 1869.[1] At that time I noted the occurrence of lunate valves with and without the central nodule, and possessing profiles and structural characteristics sufficiently distinct from those of *Hemidiscus cuneiformis*, Wall.,[2] by the absence of the marginal series of points and the much greater delicacy of the radiating granulation, to justify the establishment of a new species. I then had a presentiment, which has now been verified by actual observation, that the two lunate forms, the one with and the other without the nodule, should be indicated as the inferior and superior valves of the same species; and it may be well here to append the definition of the species then established which is reproduced on Plate XII. fig. 1, so as to rectify the generic name, and to note the presence of a nodule on the inferior valve:—

Euodia (*Hemidiscus*) *inornata*, Cstr.—Valvis lunatis; linea dorsali parabolica, ventrali late arcuata; punctulis vel denticulis marginalibus nullis; nodulo marginali in inferiori valva. In mari Atlantico Septentrionali et in Oceano Pacifico.

Euodia recta, n. sp. (Plate XII. fig. 3.)

E maximis; linea dorsali late arcuata, ventrali recta; cellulis subradiantibus; apicibus acuto-rotundatis. In Oceano Atlantico meridionali.

Among the Euodiæ brought home by H.M.S. Challenger this form is distinguished by its singular outline and its large dimensions. It is 132 μ in diameter, and its straight ventral line resembles the chord of an arc formed by the curved dorsal margin. The extremities are acutely rounded, and the sculpturing is cellulate and subradiating.

The specific name of this Atlantic species has reference to the character of the ventral side.

Euodia orbicularis, n. sp. (Plate XII. fig. 15.)

Forma minima, inflata; linea dorsali curvata, ventrali arcuata; apicibus obtusis; minimis punctulis conferta. In Oceano Atlantico meridionali.

[1] *Atti Accad. Pontif. d. nuov. Lincei*, March 1871.

[2] *Micr. Journ.*, vol. viii. p. 42, pl. ii. figs 3 and 4.

In this small form the ventral line is almost as arcuated as the dorsal, so that the outline is suborbicular or approximately elliptical. The extremities are very obtuse, and the valve is delicately but irregularly punctated.

Euodia radiata, n. sp. (Plate XII. fig. 4.)

There is here represented a frustule which possesses a very different profile from the preceding, but has the same delicate striation of radiating puncta. The apices possess a hooked form, hence the varietal designation applied above. It was procured in the Atlantic Ocean.

Euodia ventricosa, n. sp. (Plate XII. fig. 5.)

Parva, subradiantibus lineis punctulata; linea dorsali admodum curvata, centrali late convexa; apicibus rotundatis. In Atlantico meridionali.

This small frustule is ornamented with subradiating lines of puncta, which are disposed in excentric curves. The dorsal line is strongly arched, while the ventral is less convex. The extremities are bluntly rounded.

The specific name has reference to the turgescence of the ventral margin.

Euodia ventricosa, n. sp., var. nov. (Plate XII. fig. 6.)

A variety which possesses a still more convex dorsal line than the typical species just described, is here shown. The ventral line, on the other hand, is less arched, but the character of the punctation and of the extremities is similar in both.

Systephania, Ehrenb.

This genus resembles the *Stephanopyxis* of Ehrenberg so strongly as to lead one to the belief that, like *Stephanopyxis*, Ehrenb., and *Creswellia*, Arnott,[1] they are identical. Professor H. L. Smith is inclined to regard the *Systephania* as simply a valve of *Stephanopyxis*, and although much may be said in favour of this view, the absolute identity has still to be demonstrated. It is indeed true that, according to Ehrenberg, the parallelism of the rows of cellules which cover the valve is to be regarded as characteristic, since this was visible in the two species then known, namely, *Systephania corona*, Ehrenb.,[2] and *Systephania diadema*, Ehrenb.;[2] but in a preparation kindly intrusted to me by Dr James Rae, R.N., and made from material procured at Richmond, Virginia, five specimens occur, one of which is figured on Plate IX. fig. 11. This undoubtedly constitutes a new and very distinct species of *Systephania*, although the cellules that occur on the valve are

[1] *Trans. Roy. Soc. Edin.*, vol. xxi. pt. iv. p. 538, pl. xiv. fig. 109.

[2] Ehrenberg, Mikrogeologie, pl. xxxiii. 15, fig. 22, and pl. xxxiii. 18, fig. 11.

only partially disposed in a parallel manner, so that in this particular the original definition of Ehrenberg ought not to be applied too rigidly.

Systephania raëana, n. sp. (Plate IX. fig. 11.)

Densius cellulata, ordinibus subparallelis, bina aculeorum corona decorata interna spinis densiusculis subregularibus, altera rarioribus et irregularibus. Fossilis ad Richmond in Virginia.

This new fossil species, which has been named in honour of Dr James Rae, R.N., differs from those hitherto recorded not only in not having the cellulation of the valve always parallel, but also in being markedly more minute. Its most distinctive characteristic, however, consists in the double corona of puncta with which it is ornamented, the inner series being more numerous and regular than the outer. The frustule was found in a collection made at Richmond, Virginia.

Systephania aculeata, Ehrenb., var. *α* nov. (Plate IX. fig. 6.)

The form here figured, which must be ascribed to the present genus, was procured in the Sea of Japan and in the vicinity of Hong Kong by H.M.S. Challenger. It possesses a convex outline, while the areolation is wide and hexagonal. A delicate but distinct corona is manifest about the middle of the radii of the valve. The character of the areolation and of the corona point to an affinity with *Systephania aculeata*, Ehrenb., although in the latter the corona is submarginal.

Systephania aculeata, Ehrenb., var. *β* nov. (Plate XXX. fig. 3.)

The valve here shown is another variety of the typical *Systephania aculeata* of Ehrenberg, its corona occupying a position much nearer the margin than that of the variety *α* above referred to.

Systephania (?) sp. (?) (Plate XXX. fig. 2.)

The beautiful disc here figured was collected near the Bermudas. It, like the preceding, is convex and ornamented by large hexagonal areolæ, while a number of irregularly disposed submarginal puncta may readily be recognised. At the periphery a band of very large cellules occurs and gives a somewhat remarkable appearance to this interesting form.

As only a single specimen of this curious frustule has been observed, its generic and specific determination must for the present remain problematical, although it may ultimately be found to belong to the genus *Systephania*.

Coscinodiscus, Ehrenb.

Among the numerous different forms of Diatoms which have hitherto been recorded, those possessing discoidal outlines are without doubt the most elegant in appearance, but they are at the same time the most rarely met with. Thus among freshwater forms they are typified by the genus *Cyclotella* and a few *Melosiræ*, while in marine collections from the sea-shore or from the washings of sea-weeds they are only found in rare cases. To Ehrenberg is due the credit of having first directed the attention of naturalists, geologists, and microscopists to the so-called Infusorial Earths, tripoli and other siliceous deposits formed by the accumulation of myriads of the siliceous remains of Diatoms that lived in bygone geological eras. Many of these deposits manifestly represent the bottoms of ancient seas which have been elevated by subterranean forces, and the examination of the organisms which they contain has revealed many new diatomaceous forms, among which discoidal frustules more beautiful and elegant than any before known, occur in great numbers. The principal type of these discoidal forms is to be found in *Coscinodiscus*, Ehrenb., a genus which has been defined by Pritchard (History of the Infusoria, p. 827) in the following manner :—"Frustules single, discoid; disc cellular or dotted, without processes, defined border, internal septa, or division into radiating compartments." Hence in brief any simple cellular or punctated disc is called a *Coscinodiscus*, while the character of this cellulation or punctation —whether strongly marked or minute, whether increasing from the margin to the centre or conversely, whether regular or without order, whether in linear or curvilinear arrangement, whether radiating or excentric, or forming a rosette or umbilicus—constitutes the differential characteristic of many species.

That the extension of research in this department of marine biology should result in the continued increase of the number of species of this important genus is not to be wondered at, and the collection procured by the Challenger Expedition is a large and interesting one. Three magnificent new species which were brought home by this Expedition have been already described by the well-known Irish microscopist, Rev. E. O'Meara, M.A., and to the first of these the name of *Coscinodiscus craspedodiscus*, O'Me.,[1] has been given on account of its very great size (Plate III. fig. 5). It may readily be seen with the naked eye, presenting the appearance of a hoop or ring, one millimetre in diameter. Its hoop-like form is due to the circumstance that the outline is somewhat convex and strongly siliceous, with large hexagonal areolæ, while the central part is very thin and so transparent that an accurately adjusted illumination is required to reveal its sculpturing and to discover the form of its smooth central areola. The second has been named *Coscinodiscus*

[1] This interesting Diatom has been defined as follows: "Diameter 0·022", centre large, free from areolation. Areoles radiate, at the margin large, hexagonal, thence somewhat compressed, decreasing in size towards the centre, and somewhat elongated. Towards the centre some of the radiate lines of areoles are somewhat shorter than others, in consequence of which the free centre has somewhat of a star-like appearance."—*Quart. Journ. Micr. Sci.*, vol. xvii. p. 561

arafusœnsis, O'Me., the specific name being probably intended for *arafurensis*—since the sea which extends from the Aru Islands to Torres Strait, where the specimen was found, is called the Arafura Sea. The frustule is a little smaller than the preceding, from which it may also be distinguished by the following circumstances, namely (1.) the subhexagonal areolæ decrease from the margin towards the centre and are stronger than in *Coscinodiscus craspedodiscus;* and (2.) the central areola is smaller, less stellate, and irregular.

The third form which was brought from Kerguelen is also an enormous disc. It has been named *Coscinodiscus moseleyi*, O'Me.[1] It is very convex, and its central rosette is formed by eight large unequal cellules or areolæ and minute subquadrate granules arranged in small radiating groups.

In examining the numerous discoidal frustules which have now to be recorded, it is by no means easy to determine the limits that are to be set to the genus *Coscinodiscus*. Some of the granular or cellular discs correspond perfectly to the generic definition above quoted, but several other forms possess so extremely delicate punctations as to surpass in this respect all known species of *Coscinodiscus*, and to render it highly improbable that they could have been observed by Ehrenberg with his comparatively imperfect microscope when he established that genus. This view is confirmed by W. Smith, who, to prove that his *Coscinodiscus concinnus* could not be confounded with the *Coscinodiscus centralis* of Ehrenberg, remarks[2] that the cellules of the former could not have been detected by means of the instrument used by Ehrenberg. But the punctations of the forms now in question are even more minute than those of *Coscinodiscus concinnus*, so that they cannot be regarded as conforming to the definition of that genus, but must be looked upon as belonging to a new genus which I shall name *Ethmodiscus*[3] on account of the exceedingly fine condition of the granulation.

Coscinodiscus arafurensis, O'Me., var. nov. (Plate II. fig. 4.)

The frustule here figured is one of the largest members of the genus *Coscinodiscus* that has to be recorded here. Its diameter is 349 μ., and it is ornamented with large radiating cellules which become smaller towards the centre, where a smooth irregular areola occurs.

Though possessing the large size just noted the present valve is smaller than that of *Coscinodiscus arafurensis*, O'Me., and much less than that of *Coscinodiscus craspedodiscus*, O'Me. With the last-named frustule, however, it has been found to be associated in a collection made in the Arafura Sea, although *Coscinodiscus craspedodiscus*, O'Me., was also obtained in great numbers in a sounding of great depth taken in the Pacific Ocean

[1] *Journ. Linn. Soc. Lond.* (Botany), vol. xv. No. 82, p. 57, pl. i. fig. 6.
[2] Synopsis of the British Diatomaceæ, vol. ii. p. 85.
[3] ἠθμος, a filter for liquids.

near the coast of South America. Between *Coscinodiscus craspedodiscus*, O'Me.—which is represented on Plate III. fig. 5, and in which the areolation corresponds exactly to that of the original except in the case of the margin, where the details could not be adequately pourtrayed—and the present frustule there is no risk of confusion, while the latter may be distinguished from *Coscinodiscus arafurensis*, O'Me.,[1] in the following respects :—(1.) It is of smaller size ; (2.) its radiating rows of cellules regularly diminish from the circumference to the centre, where there is (3.) a smooth area somewhat smaller than that of *Coscinodiscus craspedodiscus*, and terminated less irregularly than that of *Coscinodiscus arafurensis*. Notwithstanding, however, the difference in size, in the character of the areolation, and in the condition of the central areola, I am of opinion that we are here dealing with nothing more than a variety of O'Meara's typical species.

Coscinodiscus mirificus, n. sp. (Plate III. fig. 6.)

E maximis ; granulorum lineis, radiantibus ; area centrali, irregulari, grandiuscula ; cellulæ punctulorum lineis circumducuntur. Diametrum = 326 μ. Ad Hong-Kong in mari Sinensi.

This singular species is closely allied to the above-mentioned *Coscinodiscus arafurensis*, O'Me. Its diameter is 326 μ., and its large central areola has a very irregular outline. The granulation is radiating, but the granules are at the same time disposed in excentric curves which resemble the guilloché of a watch. When examined with a homogenous immersion lens and accurately adjusted light each cellule or areole is found to be bounded by a hexagonal margin of extremely minute punctiform granules (Plate III. fig. 6 *a*). This curious frustule is from the neighbourhood of Hong-Kong.

Coscinodiscus papuanus, n. sp. (Plate III. fig. 3.)

E maximis ; granulis minimis radianter per nonnullas lineas distinctiores in totidem denticulos submarginales exeuntes divisis ; centrum nonnullis rarioribus granulis notatur. Diametrum = 152 μ. In mari Arafura.

This large disc (152 μ. in diameter) is covered with radiating lines of small granules. These are separated by rows of very minute granules which pass centripetally from as many submarginal points or denticules, but disappear towards the centre. Here a few less crowded granules occur, and this circumstance serves to distinguish the present form

[1] The original observations published on *Coscinodiscus arafurensis*, O'Me., are as follows: "The form is large, diam. 0·015", however, considerably smaller than the very striking species exhibited . . . by Mr. O'Meara under the name of *Coscinodiscus craspedodiscus*, a comparison with the leading features of which would best pourtray the characteristics of the present. Here the broad margin so remarkable in the former is absent. In the present form as in it the radiate lines of areoles terminate some distance from the centre ; the central blank space, however, is much smaller, and the lines of areoles are of more equal length. Areoles of margin subhexagonal, diminishing in size towards the ends ; they are shorter, broader, and much more robust than in *Coscinodiscus craspedodiscus*."—*Quart. Journ. Micr. Sci.*, vol. xvii. p. 463.

from the *Coscinodiscus concinnus* of W. Smith, with which it agrees in its other characteristics. Although such a difference is a small one, its specific value must still be admitted. *Coscinodiscus papuanus* was collected in the neighbourhood of New Guinea.

Coscinodiscus denticulatus, n. sp. (Plate III. fig. 8.)

E maximis; striis æqualibus, radiantibus; superficie denticulis sparsim notata; margine striato distincto. Diametrum = 130 μ. In mari Pacifico.

This large Diatom is covered with uniformly radiating granules, while the surface of the valve also bears at intervals more prominent denticules. The margin is formed by a distinct band, which is delicately fluted and separated from the valve by a well-defined line. The specific name which has been applied has reference to the prominent valval denticules.

Coscinodiscus stellaris, Roper, var. nov. (Plate III. fig. 2.)

The frustule here delineated was found near the ice-barrier of the Antarctic. It consists of a very small disc which is ornamented by lines of minute radiating puncta of so great delicacy that it has been found impossible to represent them adequately in the figure. The centre is marked by a cross formed of four oblong granules analogous to those found in *Coscinodiscus stellaris*, Roper,[1] of which the present form must be regarded as a variety.

Coscinodiscus centralis, Ehrenb., var. nov. (Plate II. fig. 3.)

A variety of *Coscinodiscus centralis*, Ehrenb.,[2] is here shown. It was collected in the Sea of Japan, and only differs from the typical specimen in possessing a fluted margin which is entirely absent in the latter.

Coscinodiscus variolatus, n. sp. (Plate II. fig. 5.)

Granulis parvulis æqualibus, fasciculatim radiantibus; superficies granulis elevatioribus maculata. Ad insulas Philippinas.

The present small but very elegant disc from the neighbourhood of the Philippine Islands is ornamented with small but distinct granules, which are disposed in fascicules consisting of parallel lines. The surface is spotted and the spots result from small groups of granules which rise beside one another in the form of denticules. The specific name has reference to the pitted appearance shown by the surface of the valve.

Coscinodiscus patera, n. sp. (Plate II. fig. 6.)

Forma umbonata; area umbilicali nonnullis punctulis notata, a qua punctulorum lineæ radiantur, quandoque prope marginem cessantes. In mari Pacifico.

[1] *Micr. Journ.*, vol. vi. p. 21, pl. iii. fig. 3; Pritchard, *op. cit.*, p. 828, pl. v. fig. 83.

[2] Ehrenberg, Mikrogeologie, pl. xviii. fig. 39; Gregory, Diatoms of the Clyde, p. 28, pl. iii. fig. 49.

This Diatom was obtained in the middle of the Pacific in a depth of 2900 fathoms. As indicated in the outline adjoining the figure, it presents, when viewed from its zonal side, a hat-like appearance. From the central areola, which is marked by a group of small puncta, radiating lines of similar puncta proceed towards the periphery, although in some cases they do not quite reach the circumference of the valve. The specific name has reference to the form of the valve.

Coscinodiscus umbonatus, n. sp. (Plate II. fig. 8.)

Valvis in centro depressis, hinc elevatis, dein depresso-complanatis; punctulis radiato-fasciculatis; fasciculi totidem denticulis ad marginem signantur. In mari Pacifico.

This form, which is very closely allied to that last referred to, was found in the same collection. Like the former, it possesses an umbonate form, but the centre of its elevated part—as may be observed in the outline accompanying the figure—is notably low. The valve is punctated in a radial manner, but the punctation differs from that of the preceding in being fasciculate. The central area is ornamented with a small group of minute points in the middle. At the circumference the fasciculi are separated by means of a short series of small, closer, and more salient puncta.

Coscinodiscus (?) bifrons, n. sp. (Plate II. fig. 1.)

Frustulum valvis dissimilibus; striis egre conspicuis, et denticulorum lineis radianter signatis, in una crebrioribus et ad marginem cessantibus, in altera rarioribus et marginem attingentibus. In mari glaciali Antarctico.

On examining a preparation made near the ice-barrier of the Antarctic on 24th February 1874, a small delicate disc was recognised. This is marked by irregular radiating lines, which are sometimes interrupted by small but very salient puncta or denticules, and disappear at a short distance from the circumference. By the use of strong oblique illumination and the superior homogeneous immersion objective of Zeiss, the bottom of the valve is found to be ornamented by striæ of extraordinary delicacy, which could only be adequately represented in the figure by the use of a greater magnifying power.

A second valve, also shown on Plate II. fig. 1, was found, which exactly corresponded with the former in position and in size, but which presented a very distinct type of ornamentation, its surface being marked by sparsely disposed lines of granules or minute puncta. These all originate much nearer the margin, and some go to the centre, while others disappear sooner or later before reaching that point. It can hardly be doubted that, from the perfect coincidence of the perimeters of the two valves, we have here to deal with a species which, like *Cocconeis*, possesses dissimilar valves; yet this supposition remains to be verified by actual observation; and it may, indeed, ultimately be discovered that they are the representatives of distinct species.

Whether these valves belong to the genus *Coscinodiscus*, or to another new genus,

must for the present remain a matter of doubt, although the dissimilarity of the valves, the very delicate striation, and the radiating rows of denticules seem to point to the latter alternative. It may, however, in the meantime be treated as a species which provisionally ranks among the *Coscinodisci*.

Coscinodiscus (?) janus, n. sp. (Plate II. fig. 2.)

Valvis dissimilibus, vix conspicue striatis et denticulorum lineis a margine exeuntibus, in una valva subdensioribus, in altera rarioribus centrum attingentibus vel prius aut postea cessantibus ; ad marginem ambæ decem distinctioribus granulis notantur. Ut supra.

The two dissimilar valves here figured must be regarded as forming a single species, which is, however, to be looked upon as a doubtful member of the present genus. The valves were found in the same preparation as that in which *Coscinodiscus* (?) *bifrons* occurred, and they possess the same characteristic radiating lines of small, salient punctà, which proceed from the margin towards the centre, while they also exhibit two distinct systems of striation. The margin of each valve, however, is ornamented by eight equidistant points, or, perhaps, little protuberances, and, as in *Coscinodiscus* (?) *bifrons*, the perimeters of the two exactly coincide.

Coscinodiscus (?) dimorphus, n. sp. (Plate XVII. fig. 6.)

Minimus; valvis irregulariter, una rarius, altera crebrius punctulata (denticulata). In Atlantico meridionali.

This very minute disc also possesses valves which are dissimilarly granulated, and might therefore be regarded as belonging to distinct species, or at least to varieties of one species. They, however, belong to a single frustule which was collected in the South Atlantic.

Coscinodiscus comptus, n. sp. (Plate XIII. fig. 9.)

Forma discoidalis plurimis punctulorum lineis circumradiantibus, quorum nonnullæ prope centrum, reliquæ ad medium radii vel circiter evanescunt. In mari Antarctico.

This elegant small disc is probably closely allied to the preceding. It is surrounded at the periphery by numerous radiating striæ of small points, the majority of which proceed only a short distance towards the centre, while a few reach the margin of a smooth but small central areola. Although the aspect of the granular lines and the delicacy of the striation present obstacles in the way of regarding this form as a *Coscinodiscus*, it may for the present be enrolled in that genus. Its specific name has reference to the elegance of its sculpturing.

Coscinodiscus antarcticus, n. sp. (Plate XII. fig. 10.)

Forma parva, inordinate punctata, et raris spinulis circumfusa. Ad meridiem insulæ Heard.

This small disciform valve has some affinity to *Coscinodiscus denticulatus* (Plate III. fig. 8), inasmuch as its surface is, like that of the latter, sparsely covered with spines or denticules. Its granulation, however, instead of being disposed in a radiating manner, presents no distinct order, while its margin is not striated, but plain. The two frustules also differ greatly in point of size, and their specific values cannot be doubted.

Coscinodiscus atlanticus, n. sp. (Plate V. fig. 8.)

Cellulis æqualibus fasciculatim radiantibus a margine ad medium radii, in centro autem inordinate dispositis. In mari Atlantico meridionali.

In this elegant disc the radiating lines of granules are disposed in fascicules around the margin, but the arrangement in the central part is irregular and more or less lax. As the character of the granulation is of the greatest importance in the determination of the species of the present genus, the specific value of the valve now before us is at once obvious. It was collected in the South Atlantic.

Coscinodiscus atlanticus (?) n. sp., var. nov. (Plate III. fig. 7.)

The valve here represented differs from the typical specimen of *Coscinodiscus atlanticus* in the following respects:—(1.) The part occupied by the radiating fasciculately disposed lines of granules is considerably greater than that ornamented by irregularly arranged granules; and (2.) the sculpturing passes into the condition of very delicate striation at the margin, where a well-marked ring of considerable breadth occurs. As it is not possible to determine the precise importance of these distinctions, I regard the present form provisionally as a variety.

Coscinodiscus stellaris, Roper, var. *fasciculata*, nov. (Plate V. fig. 9.)

The valve here represented was obtained near the ice-barrier of the Antarctic, and must be regarded as a variety of *Coscinodiscus stellaris*, Roper. It is distinguished from the latter by its very delicate fasciculated granulation—a circumstance which is not mentioned by Roper in the case of his typical species, nor indicated in the figure given by that observer, and reproduced by Pritchard (see page 155).

Coscinodiscus (?) pacificus, n. sp. (Plate VIII. fig. 5; and Plate XXII. fig. 1.)

Valvis cellulosis; cellulis subhexagonalibus, inæqualibus; margine late striato. In mari Pacifico.

The valves here shown are ornamented with large subhexagonal cellules, and each possesses a wide striated border, which serves to recall the genus *Endictya* of Ehrenberg.[1] Whether they must be ascribed to the latter genus, however, cannot be determined till

[1] Ehrenberg, Mikrogeologie, pl. xxxv. A 18, figs. 6 and 7; Pritchard, *op. cit.*, p. 831, pl. v. fig. 70.

the frustule has been observed from its zonal side; they have accordingly been provisionally assigned to the genus *Coscinodiscus*, with which there at least exist marked affinities.

Coscinodiscus africanus, Janisch, var. *rotunda*, nov. (Plate XXIV. fig. 3.)

The type of which the present frustule is regarded as a variety is represented on plate lix. figs. 24 and 25, of A. Schmidt's Atlas of the Diatomaceæ.[1] The character of the granulation, which radiates from an excentric point, is the same in both, but the figures given by Schmidt are elliptical, while the valve here shown is round, and bears radiating lines which are not equidistant. These differences, however, cannot be looked upon as of more than varietal significance.

Coscinodiscus decrescens, n. sp. (Plate XII. fig. 14.)

Valvis striato-cellulosis; cellulis grandiusculis a centro ad marginem minuentibus; margine nonnullis punctulis (denticulis) signato. Ad mare Philippinarum.

This minute disc, from the Philippine Sea, is distinguished by the large hexagonal cellules which are found on its central part, but which decrease in size towards the periphery. The margin is ornamented with a few more salient points which render it more distinct and prominent.

Coscinodiscus ebulliens, A. S., var. nov. (Plate V. fig. 1.)

The frustule here delineated is adorned with irregular cellules, which are irregularly distributed, the larger usually occupying a well-marked area about half-way between the centre and the periphery. Although presenting marked affinities with *Coscinodiscus ebulliens*, A. S., which is shown on plate lxi. figs. 11 and 12 of Schmidt's Atlas, it may be readily distinguished from the latter by the possession of a neatly striated margin, which is not represented in the typical species.

Coscinodiscus undulatus, n. sp. (Plate VIII. fig. 3.)

E maximis; cellulis subradiantibus hexagonis; valvis concentrice undulatis; centrum granulo vel cellula vacat. Diametrum = 390 μ. In Oceano Pacifico.

This superb disc, which measures not less than 390 μ. in diameter, is ornamented with large hexagonal cellules, except at the centre, where a small smooth space occurs. Its surface is broadly undulated, so that under the microscope the cellules seem to occur in alternate zones—a circumstance which has suggested the specific name.

[1] In a note appended to the explanation of his figure of the typical species Schmidt says: "Peripherie elliptisch, Mitte der Sculptur stets zur Seite geschoben."

Coscinodiscus obovatus, n. sp. (Plate VIII. fig. 4; Plate XVIII. fig. 7; and Plate XXII. fig. 9.)

Valvis obovatis; cellulis æqualibus ad marginem radiantibus, medio decussatis. In mari Pacifico.

The valves represented in the present figures all possess an oval outline. The cellules are arranged in rows which proceed from the periphery towards the centre, but around this point the ornamentation varies in character, although it often assumes a simple linear and decussate arrangement. In the form shown in Plate XVIII. fig. 7, which may be regarded as the typical form, the margin is provided with an undulating line. The frustules were all found in the Pacific Ocean.

Coscinodiscus curvatulus, Grun., var. nov. (Plate III. fig. 10.)

In this figure there is represented a very small disc which is richly covered with granules, disposed in seventeen radiating lines, passing from the periphery to the centre. Each line originates at a marginal indentation, and the granulation between the lines is arranged parallel to them in each intermediate area. This valve can only be regarded as a variety of *Coscinodiscus curvatulus*, Grun.,[1] in which the lines, instead of being straight, are slightly curved—a distinction which is of little importance.

Coscinodiscus reniformis, n. sp. (Plate XII. fig. 12.)

Frustulum reniforme; striis radiantibus; cellulis grandiusculis, ad centrum minuentibus.

This novel valve possesses a reniform outline, and is ornamented with radiating cellules which decrease in size towards the centre. That it is a normal and not a teratological form is shown by the circumstance that several specimens have been observed either entire or in fragments from different and widely separated localities.

Coscinodiscus lentiginosus, Janisch. (Plate V. fig. 4.)

Mediocris, punctulorum lineis radiantibus, rariusculis, interruptis. In mari Antarctico.

At Station 146, off Marion Island, lat. 46° 46′ S., long. 45° 31′ E., in a depth of 1375 fathoms, the valve here figured, along with many other discoidal forms, was obtained. The entire collection has already been reported on under No. 207 of the interesting series of Diatoms edited by Cleve and Möller, but I am not aware that the present species has been referred to by Janisch in any other publication. Although the naming of a species in a preparation is not regarded as equivalent to the publication of the form, yet the designation *lentiginosus* given by Janisch is so apposite that it has been retained here.

[1] A. Schmidt's Atlas, pl. lvii. fig. 33: "Die radialen Krümmungen haben in den beiden Schalen eine entgegengesetzte Richtung."

The frustule is of moderate size, and bears radiating but interrupted lines of thinly disposed granules.

Coscinodiscus polyradiatus, n. sp. (Plate III. fig. 4.)

Granulis æqualibus in lineis parallelis distributis, superficiem in pluribus triangularibus dissepimentis dividentibus; margine lato, striato. Ad mare Antarcticum.

This elegant disc was collected in the Antarctic Ocean. It is divided by several radiating lines into a number of triangular areas. These lines are made up of granules of uniform size, and parallel rows of similar granules are disposed in the intermediate areas until the whole of the central part of the disc is covered. This is inclosed by a large striated border—a circumstance which especially distinguishes it from *Coscinodiscus fasciculatus*, A. S.,[1] while a narrow peripheral margin bearing concentric rings is also present. That this frustule constitutes a good species cannot be doubted.

Coscinodiscus gemmatulus, n. sp. (Plate XVII. fig. 9.)

E minimis; margine lato, punctulato; medio raris granulis vel margaritis in irregulares et raros ordines radiatim dispositis. In mari Indico.

This small but elegant disc is surrounded by a large striated and punctated marginal belt. The centre is ornamented with sparsely disposed lines of rare granules which do not reach the centre.

Coscinodiscus cycloteres, n. sp. (Plate XXII. fig. 8.)

E minimis; disciformis, valvis margine hyalino et zona granulata distinctis, a qua æqualium granulorum lineæ procedunt, nonnullæ ad centrum, aliæ plus minus breviores; lineæ centrales ab elevatiori granulo vel denticulo oriuntur. In mari glaciali Antarctico.

This elegant small disc possesses a hyaline margin within which a densely granulated belt runs round the valve. From this belt a series of granulated lines proceed towards the centre, and of these a few almost reach that point, while the others are shorter and of different lengths. The lines which pass almost to the centre originate at the inner border of the hyaline margin in somewhat salient granules or denticules.

Coscinodiscus (?) polygonus, n. sp. (Plate XXII. fig. 6.)

Valvis polygonis finissime striolatis; superficies plurimis denticulorum lineis irregulariter distributis et interruptis ornata. Ut supra.

Among the collections made in the Antarctic Ocean polygonal discs fringed by a very delicate dentation are not unfrequently met with. The surface of the valve in the present case is ornamented by numerous radiating lines of small points or denticules—the lines

[1] Compare A. Schmidt's Atlas, pl. lvii. figs. 9 and 10.

being irregular and irregularly interrupted. The centre of the valve is for the most part smooth and bears only a small group of granules. Although it is not possible to determine the cause of the polygonal form it may be conjectured that it has resulted from the detachment of its outer border. The generic and specific determinations which have been given are to be looked upon as provisional—(1.) because the surface of the valve, like those of several of the species above enumerated, is very delicately striated, and (2.) because the outline here presented is probably abnormal.

Coscinodiscus megacoccus, n. sp. (Plate XVII. fig. 2.)

E minimis; cellulis vel areolis subhexagonalibus grandiusculis; margine cellulis subquadratis constituto. In Oceano Pacifico.

This very minute organism from the Pacific Ocean is singular in being covered by a limited number of large cellules and by possessing a distinct border of cellules or subquadrate granules. In these respects it presents affinities with the similarly ornamented *Coscinodiscus subconcavus*, Grun., which is figured in Schmidt's Atlas, plate lxii. fig. 7. It may, however, be readily distinguished from the latter—(1.) by its much smaller diameter, and (2.) by the fact that the cellules are notably larger than in any other known species.

Coscinodiscus (?) rudis, n. sp. (Plate XXII. fig. 4.)

Forma distinctis granulis æqualibus elevatioribus grandiusculis instructa, rudem superficiem efficientibus. Ad insulas Philippinas.

The generic determination of this disc, from the Philippine Islands, must be looked upon as provisional, as it may ultimately be found to belong to the genus *Pyxidicula*, Ehrenb., its valve being sufficiently convex to entitle us to express such a conviction. It is distinguished by its large and distinctly elevated papillæ or granules, which are hexagonal at the base, but orbicular at the summit. On account of these papillæ the external surface, when seen from the zonal aspect, is tuberculated in appearance—a circumstance which has suggested the specific name.

Coscinodiscus (?) venulosus, n. sp. (Plate XVII. fig. 1.)

Forma minima, centro lineolis sinuosis radiantibus distincto. Ad meridiem insulæ Kerguelen.

This small hyaline disc was observed in a collection made to the south of Kerguelen. It only shows a corona of tortuous and ill-defined lines around the centre, where a smooth irregularly bordered area occurs. Although I have provisionally placed this curious valve among the *Coscinodisci*, its generic determination is by no means free from doubt.

Coscinodiscus (?) sp. (?) (Plate X. fig. 10.)

The form which is represented in this figure is up to the present time unique and must be looked upon as an organism of a very uncertain nature. The valve is oval, and provided with a wide hyaline border. The surface is covered with uniform, densely, but irregularly disposed granules, and the boundary between the hyaline and granulated surfaces is irregular in form. The specimen figured is the only one which has been observed, and occurs in a preparation made by Dr Rae, and kindly placed by him at my disposal. This being so, the exact systematic position which should be assigned to it must in the meantime remain a matter of doubt, though it may be provisionally assigned to the genus *Coscinodiscus*. It was collected in the neighbourhood of Zebu, one of the Philippine Islands.

Coscinodiscus diophthalmus, n. sp. (Plate XVI. fig. 4.)

Valvis cellulosis, duplicem præbentibus areolam ovalem depressam; cellulis rotundis grandiusculis ad centrum decrescentibus. In mari Pacifico.

Among the many interesting preparations made by Dr Rae and forwarded to me by Mr John Murray, were some labelled *Coscinodiscus excavatus*, which could not be reconciled with the Diatom so named by Greville. The latter has been defined in the following manner by Pritchard:[1]—"Disc large, with hexagonal cellules decreasing in size towards the centre, which has three conspicuous depressions alternating with the same number of elevations." On the other hand, the valve now in question possesses *round* cellules, while, in place of the three alternating elevations and depressions, there exists two large depressed oval hyaline areas, which appear as perforations, and an equal number of slight elevations. Unless these structures can be compared with the two processes of the genus *Auliscus*, Ehrenb., they find no analogy among other known Diatoms. The depressions do not certainly show that they are closed by a siliceous plate, since in the interior and at a lower level no other cellulated wall could be discovered, yet the valve cannot be considered as an abnormal or teratological one, because it has been recognised in three collections which were made in widely separated localities in the Pacific Ocean. The true systematic position of this Diatom must accordingly for the present remain a matter of doubt. The specimens observed have been of different dimensions, and the large round cellules ornamenting the valves were observed to decrease slightly in size towards the centre.

Coscinodiscus diophthalmus, n. sp., var. *monophthalma*, nov. (Plate XVI. fig. 7.)

This variety is provided with a single perforation-like depression and a single elevation. The general sculpturing of the valve resembles that of the preceding species, and, like the latter, the present form was collected in the Pacific Ocean.

[1] Pritchard, *op. cit.*, p. 829 pl. viii. fig. 26; Schmidt's Atlas, pl. lxv. fig. 1.

Coscinodiscus rhombicus, n. sp. (Plate XXII. fig. 11.)

Forma rhomboidalis, apicibus rotundatis; granulis ad centrum rariusculis nullo certo ordine, ad marginem crebescentibus et sensim in strias radiantes transeuntibus. In mari Japonico.

This elegant valve from the Sea of Japan possesses a rhomboidal outline. The central space is ornamented by well-defined granules which are free from one another, and arranged in no definite order. They decrease in size, but become more numerous towards the margin, and finally pass into the condition of delicate radiating striæ. In its general characters this Diatom recalls the genus *Cestodiscus*, but the absence of rare distinct and salient granules around the margin prevent it from being ascribed to that genus. The specific name has reference to the form of the outline of the valve.

Coscinodiscus lanceolatus, n. sp. (Plate XVII. fig. 19.)

Forma parva, elliptico-lanceolata, granulis vel cellulis stipata a centro radiantibus et decrescentibus. Ad meridiem Australiæ.

This elliptico-lanceolate form was procured in the neighbourhood of Sydney, South Australia. It is densely covered with irregular granules or cellules, which decrease in size as they pass from the centre towards the circumference.

Coscinodiscus ovalis, Roper. (Plate XVII. fig. 18.)

This form was found in a sounding made near Yedo, in the Sea of Japan. The frustule exactly corresponds to those in a collection of *Coscinodiscus ovalis*, Roper,[1] which was given to me by the well-known French microscopist Alphonse de Brébisson, and it shows marked differences from any of the preceding types.

Coscinodiscus margaritaceus, n. sp. (Plate XVIII. fig. 3.)

Mediocris; valvis margaritarum subæqualium seriebus ab area centrali radiantibus distinctis, quæ abrupte ad marginem in punctulorum lineolas transeunt. In mari Antarctico.

In its general characters this Antarctic valve is closely allied to the genus *Cestodiscus*. Its form is circular, and it is ornamented by rows of beautiful cellules, which are disposed in radiating lines. The central area is smooth and irregular. Towards the periphery the granules suddenly become small, so that the border is formed by thickly disposed lines of minute points. It differs, however, from the *Cestodisci* in possessing no prominent points or processes around its circumference, and it must accordingly be looked upon as a specific form of the genus *Coscinodiscus*.

[1] *Micr. Journ.*, vol. vi. p. 22, pl. iii. fig. 4, 1858; Pritchard, *op. cit.*, p. 831, pl. v. fig. 78.

Coscinodiscus radiatus, Ehrenb., var. *abyssalis*, nov. (Plate XXIX. figs. 2, 11, and 15.)

These figures represent a *Coscinodiscus* which was found in the interior of two Echini procured from a depth of 1340 fathoms at Station 47, lat. 41° 14′ N., long. 65° 45′ W. The differences observable between the frustules tend, however, to lead one to believe that one has to deal with forms having no relation to one another. The drawings have been made from the appearance presented by one valve mounted in a dry air cell instead of Canada balsam, and in such circumstances when examined under the most perfect homogeneous immersion objectives, constructed by Zeiss of Jena, or by Reichert of Vienna, and others, a different image is obtained at each slightest focal change, so that it is not easy to determine which should be regarded as typical. These different appearances, however—apart from those caused by diffraction—reveal the minute details of the ornamentation of the organism. Thus, although I regard the very small granules which limit the hexagonal areolæ in fig. 2 to be a real structural peculiarity, they cannot be observed in Canada balsam preparations. In the latter preparations the surface is found to be covered with areolæ, which radiate from the centre to the periphery, where they gradually diminish in size, so that it presents affinities to *Coscinodiscus radiatus*, Ehrenb.[1] On comparing it, however, with the specimen of that species given in the Typenplatten of Möller, the areolæ are found to differ in size in the two cases, being in the new form about one-third larger. Thus it must be regarded as a variety of Ehrenberg's species, its varietal name having reference to the fact that it was procured in deep water in the Atlantic. It is desirable that the two forms should be accurately compared when both mounted in the dry state.

Willemöesia, n. gen.

Several of the curious and interesting forms shown on Plate VIII. figs. 8, 8 *a*, and 8 *b*, have been observed from different localities. The three frustules represented are all elongated, and are closely related to one another. All are granulated, but in the first the granules are disposed in an indefinite manner, while in the second and third the punctations are uniformly distributed over the valves, being in the second decussate, but in the third irregular. The form of the first is long and cuneate, while that of the others is sublinear, but in all three one extremity is cuneately, while the other is simply, rounded.

The fact that several specimens of these forms have been observed from different localities is opposed to the belief that they are teratological or anomalous forms, and as they all present some common characteristics, while each retains its own special and distinctive marks, they may well be regarded as three types of a new genus.

[1] Ehrenberg, Mikrogeologie, pl. xxi. fig. 1; Smith, Synop. Brit. Diat., pl. iii. fig. 37; Pritchard, *op. cit.*, p. 830, pl. xi. figs. 39 and 40.

This genus has been named in honour of Dr Rudolph von Willemöes-Suhm, one of the naturalists on board H.M.S. Challenger, who died during the Expedition.

A more precise statement of generic and specific characters may in the meantime be omitted pending a further series of observations on this very interesting group of organisms.

Ethmodiscus,[1] n. gen.

Frustula solitaria, discoidalia; valvis tenuissime et inconspicue striolatis; forma plus minus convexa, quandoque diversimode denticulata; zona connectiva punctulata.

Under the genus *Coscinodiscus*, which is well adapted for the reception of species having conspicuously granulated markings, the desirability of establishing a new genus for certain forms possessing an almost invisible sculpturing was alluded to. For this new genus the name of *Ethmodiscus* is here adopted, a word which has reference to the presence on the valves of extremely delicate points, which may be compared to the fine pores of a filter. Although such forms could not have been accurately observed by the use of the relatively imperfect microscopes employed by Ehrenberg, and although it is with the greatest difficulty and by the use of the greatest obliquity of illumination that the best instruments of the present day can reveal the exquisite delicacy of their ornamentation, yet the opportuneness of establishing the genus has been proved by the discovery in surface gatherings of certain discoid forms of enormous size and extreme fragility, which are characterised by their very minute granulations.

The form of the valves of the specimens bearing these delicate markings—which cannot be made out when they are mounted in balsam, but become visible in dry preparations—is found, when they are broken by the action of the flame of a spirit-lamp, to be notably convex.

The existence of large fragments of frustules, which must also have belonged to Diatoms of extraordinary size, and which bear characteristic punctations (Plate XIV. figs. 4 *a*, 4 *b*, 4 *c*), had often been revealed by the examination of organic siliceous forms derived chiefly from soundings. These fragments, however, remained undetermined, and their true significance has only recently been disclosed by preparations made on board the Challenger. One of these preparations includes three large cylindrical Diatoms terminated by two notably convex surfaces (Plate XXII. fig. 10), and provided with hoops or connecting zones showing punctations arranged in a quadrate manner. This would lead one to believe that the fragments in question belonged to the connecting zones of Diatoms of this genus; and this belief has now been proved by the recognition in one of these fragments of converging lines of small points, along with a similar quadrate sculpturing on a portion adhering to its margin. The difficulty of finding any converging lines or any

[1] ἠθμος, a sieve.

parts connected with these fragments may be explained by the long cylindrical forms of the frustules.

The following are the essential characteristics of the genus *Ethmodiscus*:—(1.) The extremely delicate granulation or striation of the frustule; (2.) the discoidal form and notable convexity of the valves; (3.) the great development of the connecting zone, which may sometimes cause the axial line to exceed the length of the transverse diameter; (4.) the presence of small points arranged in a quadrate manner on that zone; and (5.) the frequent occurrence of distinct elevated granules, which rise upon the valves in a coronal or radial manner.

The following new species are included in this genus:—

Ethmodiscus punctiger, n. sp. (Plate III. fig. 1.)

Valvis convexissimis, finissime radiato-punctulatis, denticulorum corona marginali decoratis, et ad marginem granulorum ordine signatis. Diametrum = 143 μ. Prope Yedo, in mari Japonico.

This large and beautiful disc comes from a very interesting collection of pelagic Diatoms made in the Bay of Yedo. It possesses a very convex form, and is ornamented with delicate radiating punctated striæ. It has a submarginal corona of distinct points or denticules, and its border is marked by a row of very small granules.

Ethmodiscus convexus, n. sp. (Plate III. fig. 9.)

Valvis admodum convexis subinconspicue punctulatis; denticulis medio raris, ad marginem dense ordinatis. Diametrum = 123 μ. In mari Arafura.

This beautiful species was found in the Arafura Sea. Its disc is markedly convex, bears an almost invisible striation, and is ornamented with very minute denticules, while near its periphery a circle of similar denticules is also found. This species cannot be confounded with any *Coscinodiscus* on account of the extreme delicacy of its ornamentation and the decided convexity of its valves, which is equal in extent to two-thirds of their radius. The specific name has reference to the form of the valves.

Ethmodiscus radiatus, n. sp. (Plate XII. fig. 9.)

Forma grandiuscula finissime striolata; zona lata marginali inordinate granulata, a qua granulorum radii plus minus ad centrum pergunt; media superficies nonnullis granulis sparsa; distinctiorum granulorum corona marginali. In mari Arafura.

This species is also from the Arafura Sea. It is of discoidal form and bears extremely delicate striæ. It exhibits, towards the margin, a large belt of small granules confusedly disposed, and from this belt there run towards the centre several straight rows of granules.

These rows, none of which reach the centre, are of different lengths. The central space bears a number of irregularly scattered granules, while the periphery is marked by minute striæ and is adorned by a beautiful corona of distinct granules.

Ethmodiscus japonicus, n. sp. (Plate XXII. fig. 2.)

E maximis; valvis vix perspicue radianter striatis; margine finissime striolato, et brevium distinctiarum lineolarum corona decorato. Ad sinum Yedo, in mari Japonico.

A rich gathering of pelagic Diatoms made with surface nets in the Bay of Yedo contained this magnificent hyaline disc, which, in a dry preparation, measured 145 μ. The very delicate marginal hoop, under oblique illumination, reveals a very fine striation. The corona consists of beautiful small radiating lines, and the valve is covered by very delicate, almost invisible, radiating bands.

The specific name has been derived from the locality in which it was first recorded.

Ethmodiscus japonicus, n. sp., var. nov. (Plate XVI. fig. 1.)

We have here represented a form which resembles *Ethmodiscus japonicus*. It may be distinguished from the latter, however, by having the intervals between the short small lines which adorn the perimeter of the disc somewhat narrower and by being of smaller size.

Ethmodiscus coronatus, n. sp. (Plate XXII. fig. 7.)

Mediocris; valvis tenuissime striolatis, duplici alterno granulorum ordine marginali coronatis, et raris granulis sparsis. Ad mare Arafura.

This species is rather small but elegant. It possesses a discoidal surface which is delicately striated, and bears a few irregularly disposed round granules. There is also present a beautiful corona formed by two alternate rows of granules which are thinly scattered around the margin of the valve.

Ethmodiscus coronatus, n. sp., var. α and β. (Plate XII. figs. 7, 13.)

Two varietal forms of the preceding species are here figured. They differ from the typical frustrule in having a marginal corona which, instead of being regular and formed by two alternate lines, is irregular and of several rows.

Ethmodiscus humilis, n. sp. (Plate XVII. fig. 4.)

Forma minima discoidalis, granulo centrali et granulorum ordine circum signata. In mari Antarctico.

This species is from a depth of 325 fathoms. It occurred among mud in a sounding taken among the ice-masses of the Antarctic. Its form is that of a small disc which bears a single granule in the centre, and a marginal line of similar granules.

The simplicity of the ornamentation of this form has suggested its specific name.

Ethmodiscus obovatus, n. sp. (Plate XVII. fig. 5.)

Forma minima late obovata, nodulo grandiusculo umbilicali, raris punctulis circum sparsis, et margine distinctioribus granulis signato, instructa. Ad mare Arafura.

This type has some resemblance to the last, but its form is oval, and it exhibits a slight deviation in the regularity of its outline at one point. It possesses a large granule in its centre and its margin is also marked by a number of somewhat smaller though distinct granules. Between the marginal corona and the centre of the disc a small number of irregularly disposed rounded points occur.

Ethmodiscus perichantinos, n. sp. (Plate XXII. fig. 3.)

Forma suborbicularis, vix conspicue striolata, irregulari punctulorum agmine umbilicali, raris punctulis ad marginem et variæ magnitudinis sparsa, et punctulorum corona spinulosa cincta. In mari Arafura.

This species, of which several specimens were obtained in the Arafura Sea, has a rounded and irregular outline, and exhibits a radiating striation which is very difficult to recognise. There is an irregular group of small granules at its centre, its margin is strewn with thinly scattered puncta, and its border is granulated and thorny.

The specific name of this form is derived from the condition of its border.

Ethmodiscus diadema, n. sp. (Plate XVIII. fig. 1.)

Forma mediocris, convexiuscula, radianter striolata, margine variorum processuum corona insignita. In Antarctico, ad meridiem insulæ Heard.

This type, which was found in the icy Antarctic Sea to the south of Heard Island, possesses a disciform convex frustule. It has conspicuous radiating striæ and its margin is adorned by several (20) large granules or more salient points, which are disposed at somewhat irregular intervals.

The specific name has reference to the presence of salient marginal puncta.

The examination of several fragments of connecting zones belonging to the extremely large Diatoms already alluded to, revealed the existence of several species, of which the following are noteworthy :—

Ethmodiscus gigas, n. sp. (Plate XIV. fig. 5.)

Forma rotunda, maxima; valvis convexis inæqualibus quarum una cum area umbilicali (?); lineolis radiantibus (?); cingulo cylindrico punctulato. Diametrum = 1633 μ. In Atlantico, ad insulas Capo Verde.

This is a very large form provided with valves which are unequal, one being more convex than the other. It possesses an umbilical areola which may be of varying size,

thereby showing the uncertainty which must often exist in the definition of species when these have not been established upon living forms. Its valves and connecting zone exhibit a slight striation.

Ethmodiscus wyvilleanus, n. sp. (Plate XIV. fig. 6.)

E maximis; subcylindricum; valvis convexis medio complanatis, radiolatis; zona connectenti punctulata. Diametrum æquatoriale = 1000 μ. : polare = 1457 μ. In Oceano Atlantico.

Although smaller than *Ethmodiscus gigas*, this species is still of colossal size. Its valves are convex, and each has a flat slightly compressed centre. The connecting zone is greatly developed, so that the frustule is cylindroidal, the ratio of the equatorial to the polar axis being approximately as 2 to 3. This zone is clearly punctated in a quadrate manner, and the valves are ornamented with radiating striæ or rows of small points.

Ethmodiscus tympanum, n. sp. (Plate XIV. fig. 3.)

E maximis; exacte cylindricus; valvis annulatis cingulo inclusis. Ad superficiem maris Japonici.

This curious type is not so large as the two preceding. Its form is exactly cylindrical. It possesses, like *Biddulphia*, a distinct belt superposed to the hoops of the two valves.

The specific name has reference to its cylindrical outline.

Ethmodiscus (?) sphæroidalis, n. sp. (Plate XXII. fig. 10.)

Frustulis spherico-compressis, binatim conjunctis; valvis convexis inæqualibus, una scilicet convexo-complanata, altera convexa et medio concava. Diametrum = 882 μ. In mari Pacifico.

This species is interesting not only on account of its size, but also because two similar frustules were found associated together—a circumstance which renders the generic determination doubtful. Both forms are of a compressed spheroidal outline and are united by a common belt, which exhibits a very delicate line of suture in the middle. This belt is somewhat analogous to that which occurs in some *Melosiræ* and *Podosiræ*. On each frustule two other lines, which probably indicate the incapsuling of the two valves, occur.

It is to be noted that, although the character of the belt seems to indicate a relationship to the *Melosiræ* and *Podosiræ*, its size and fragile nature point to an affinity with *Ethmodiscus*.

Plate XIV. figs. 4, 4*a*, 4*b*, 4*c*, represent fragments of various species.

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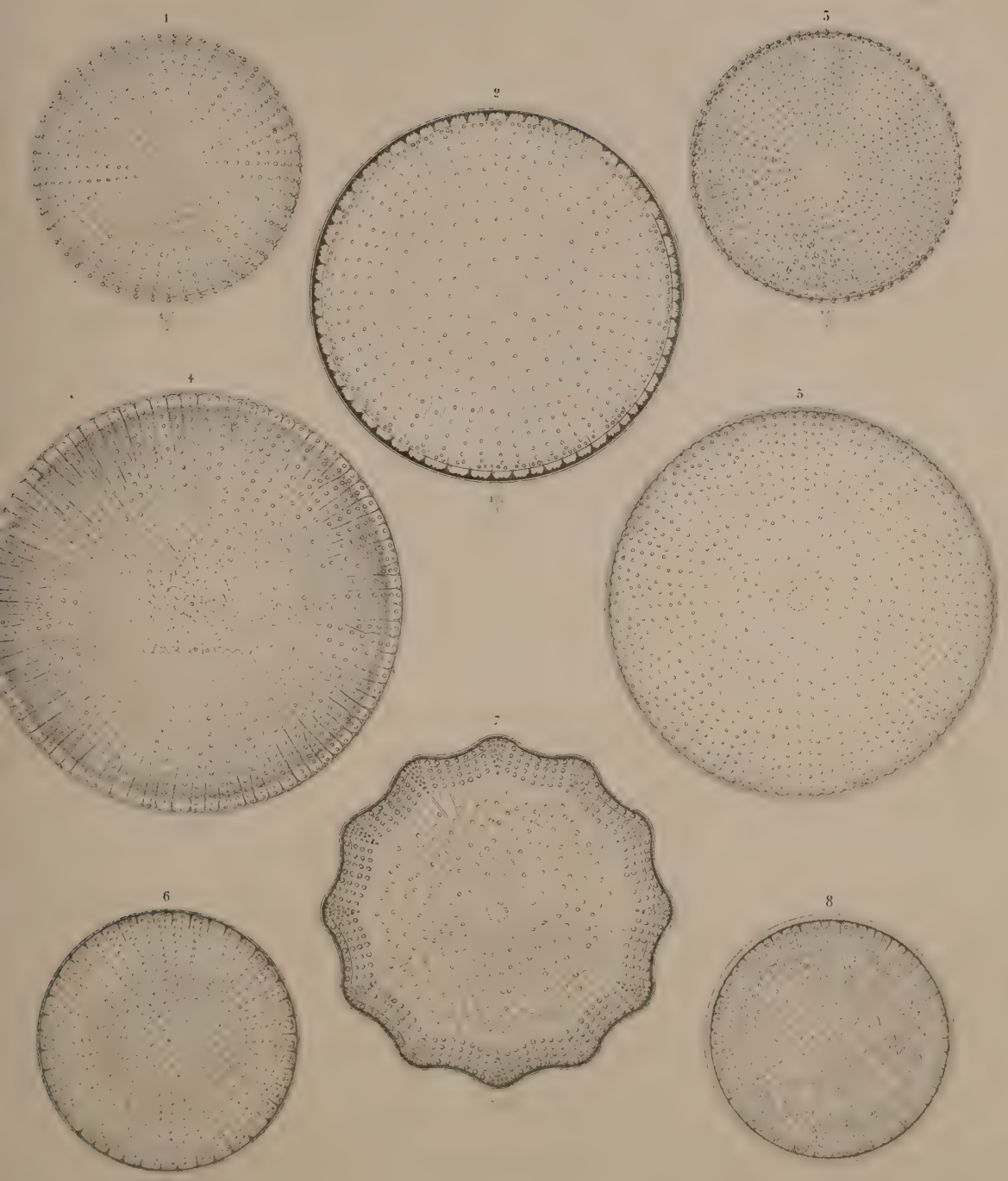
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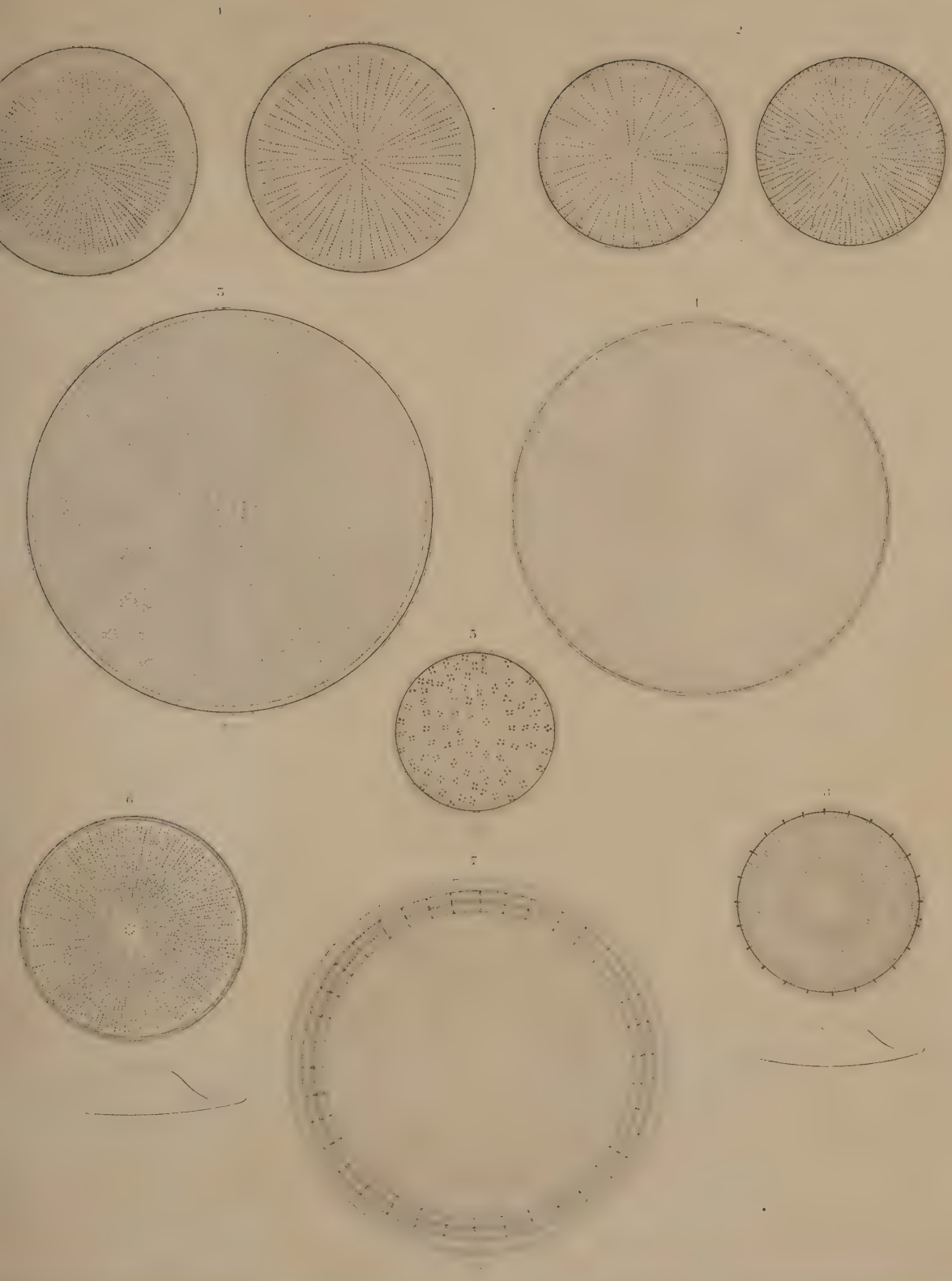

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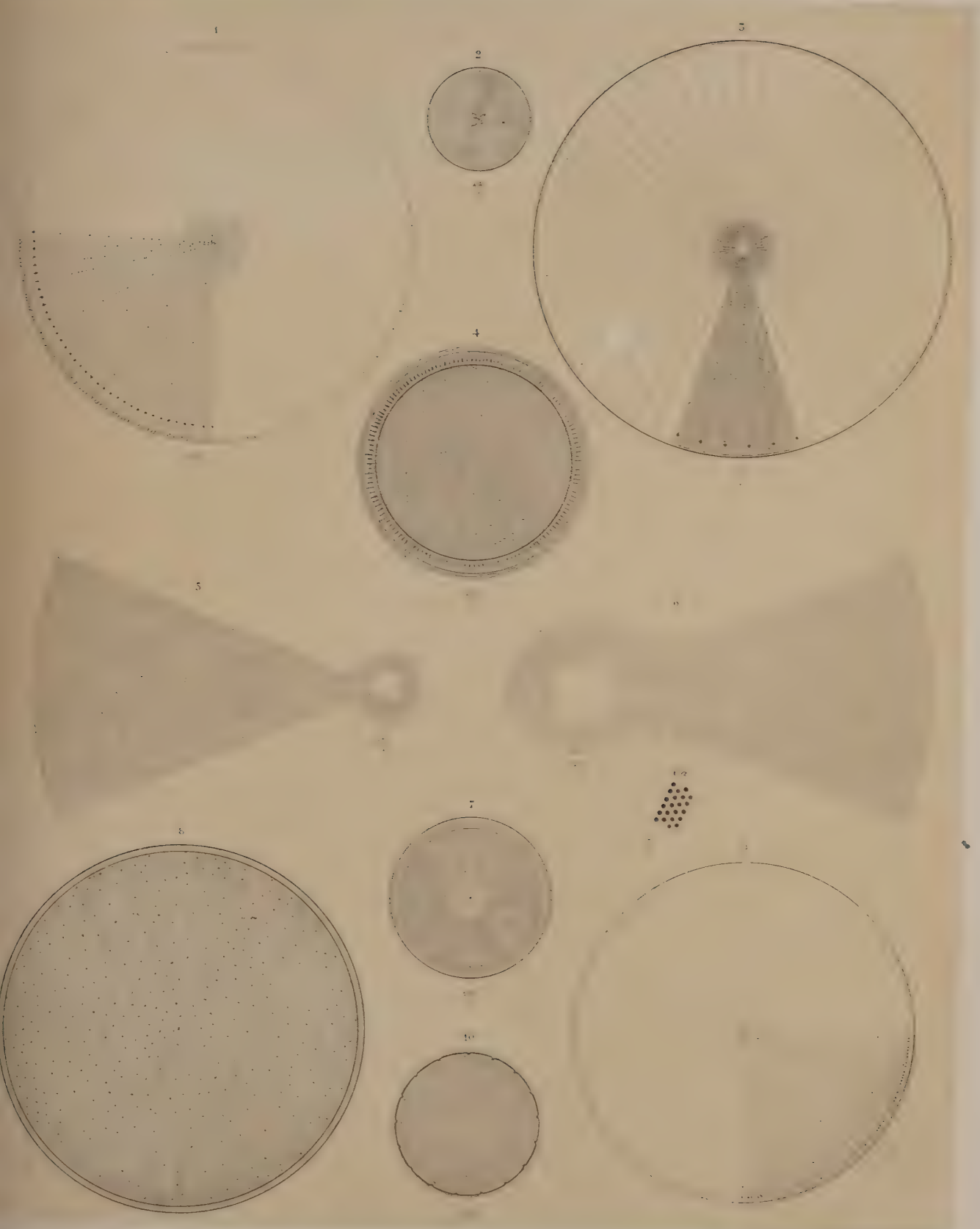
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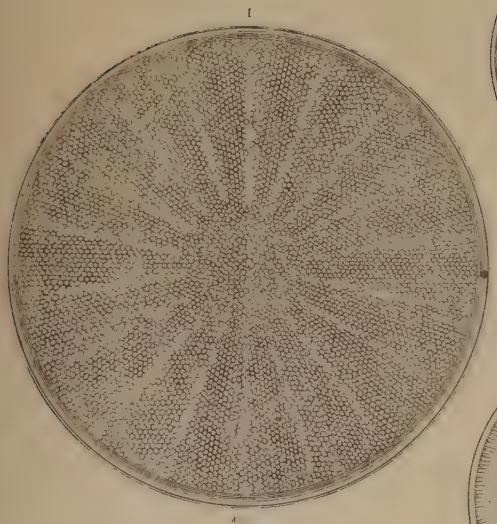
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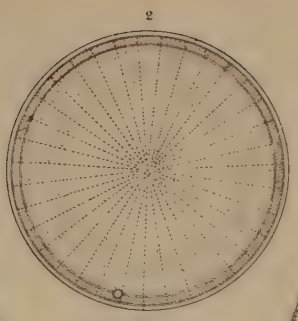
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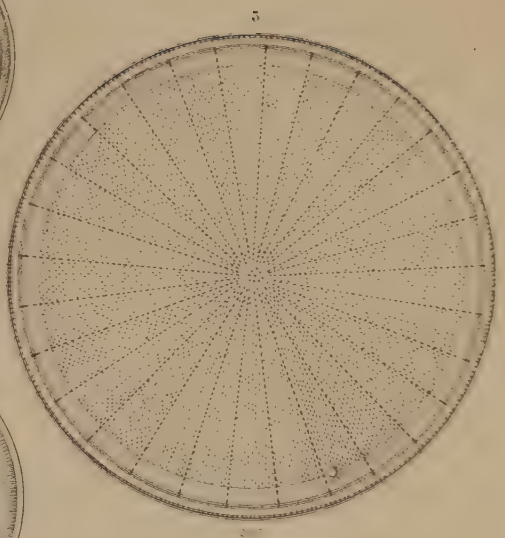
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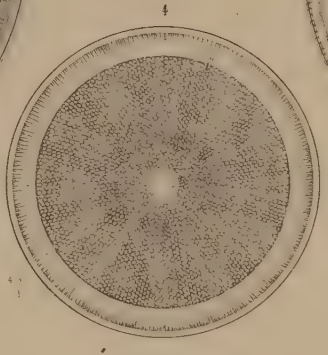
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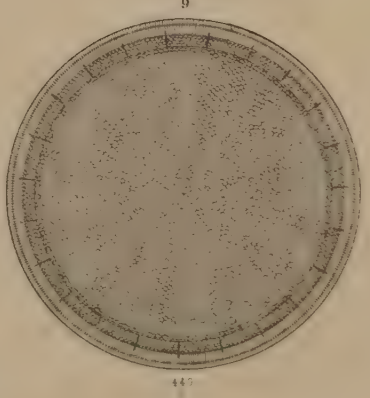
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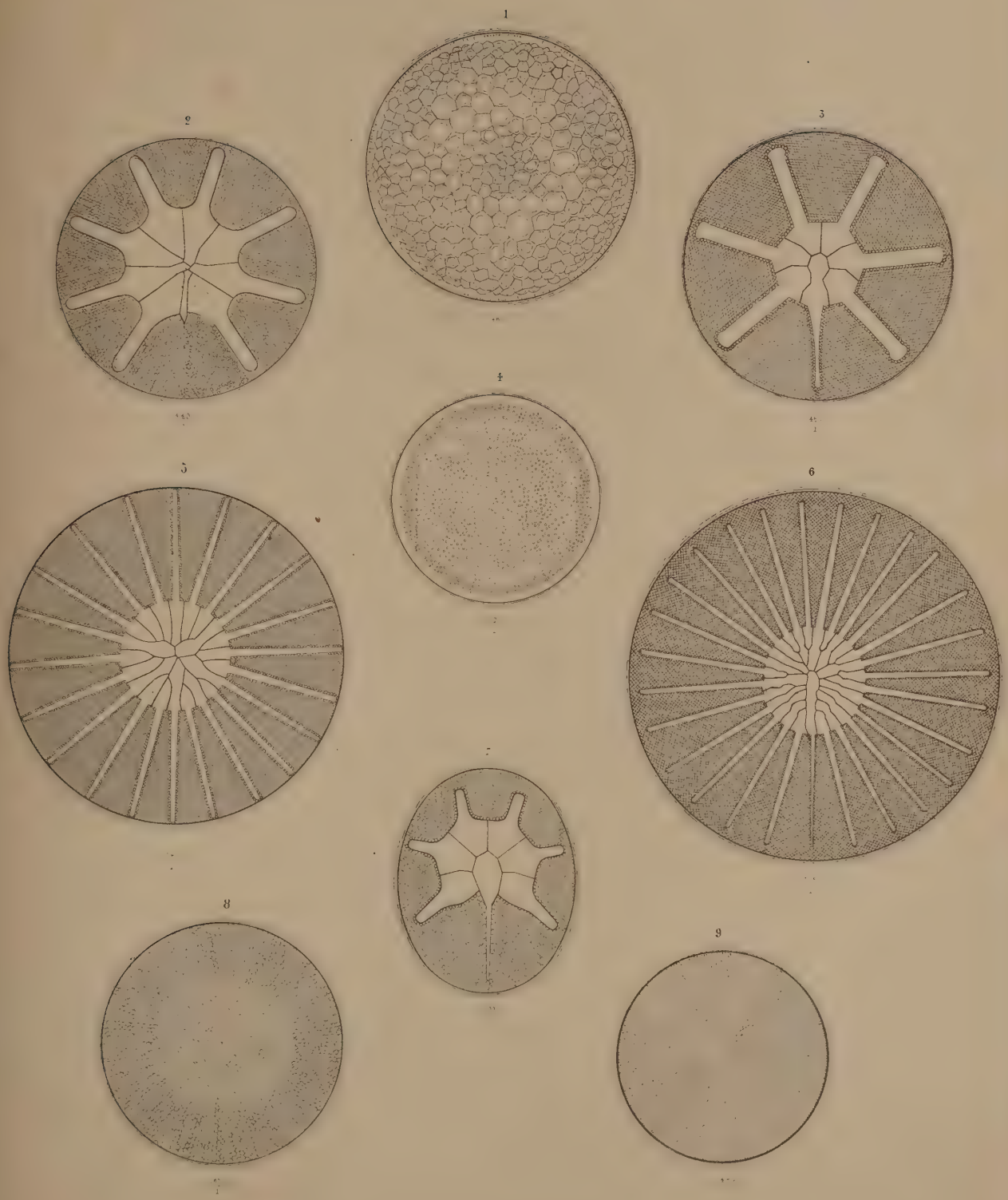
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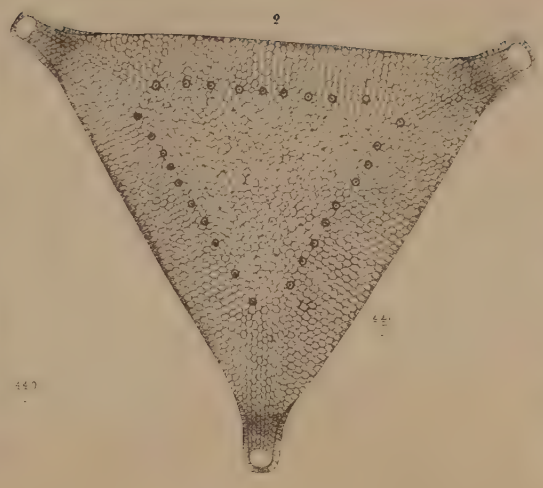
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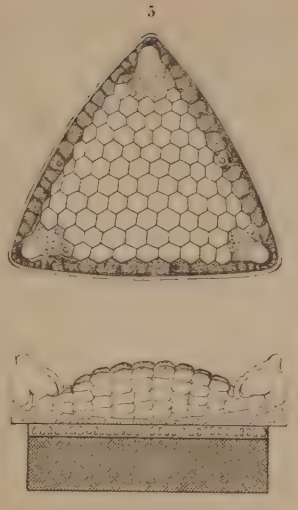
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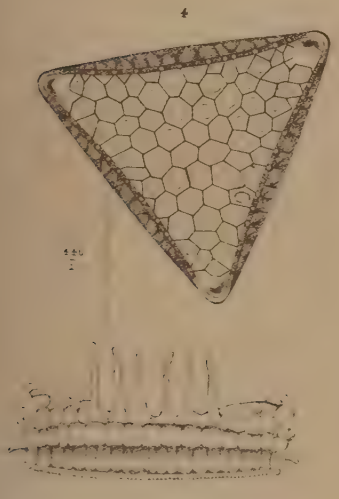
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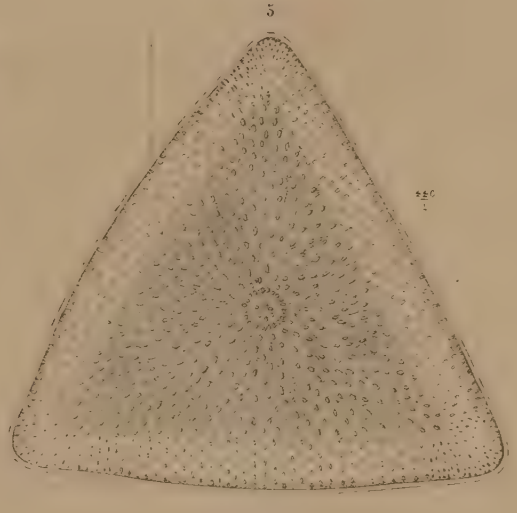
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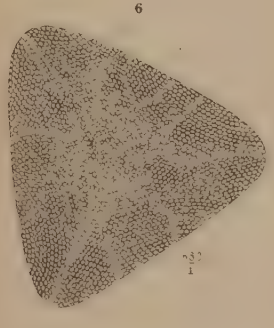
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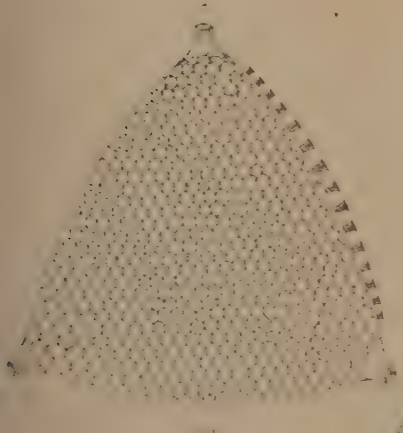
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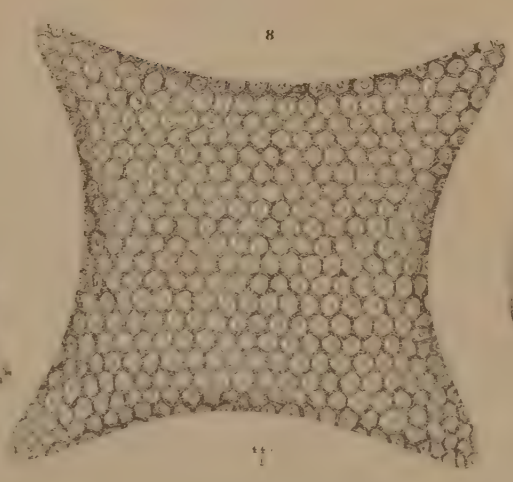
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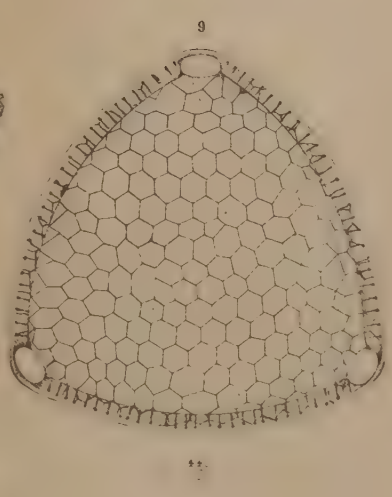
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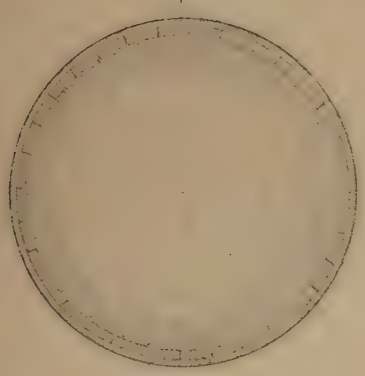

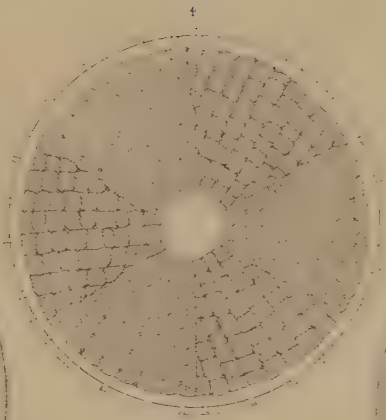

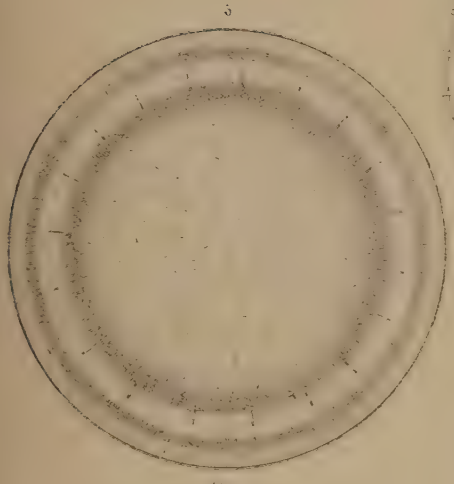

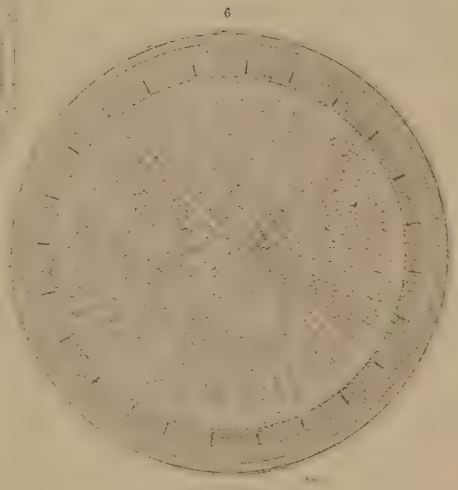

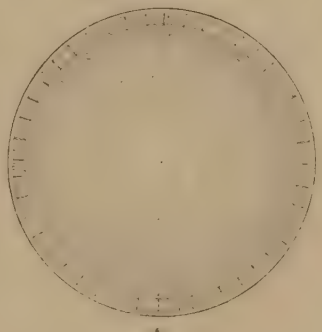

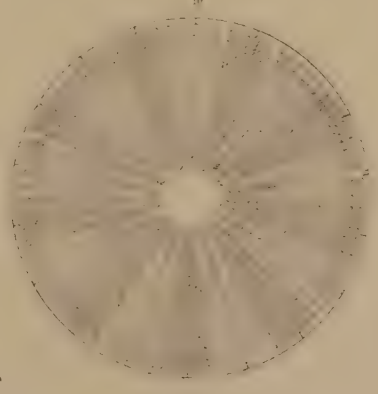

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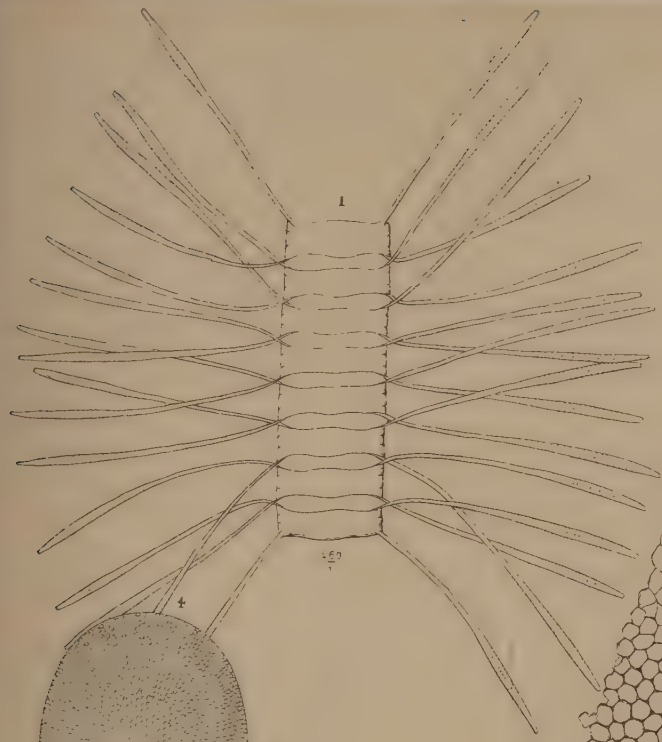

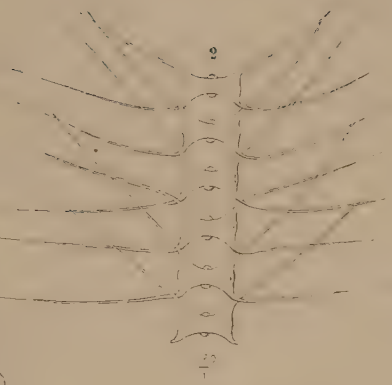

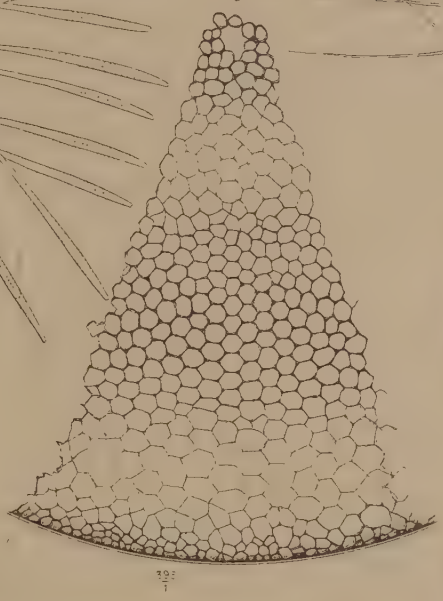

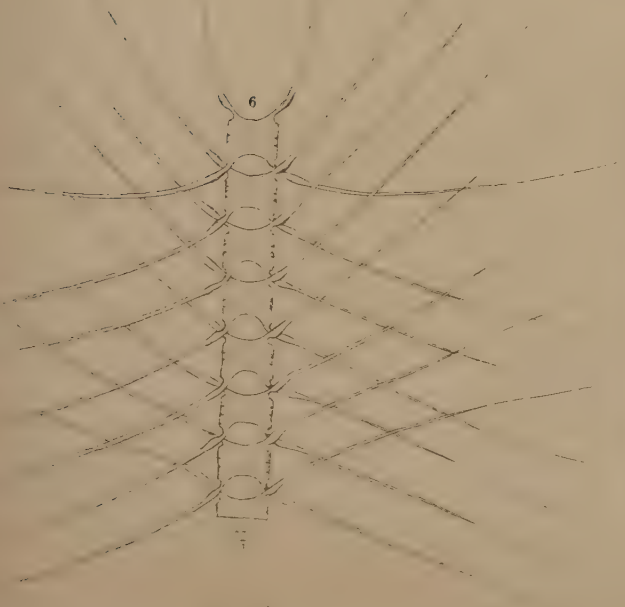

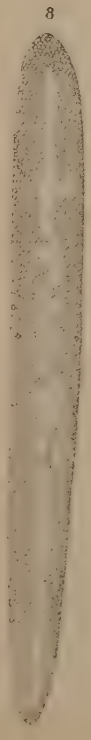

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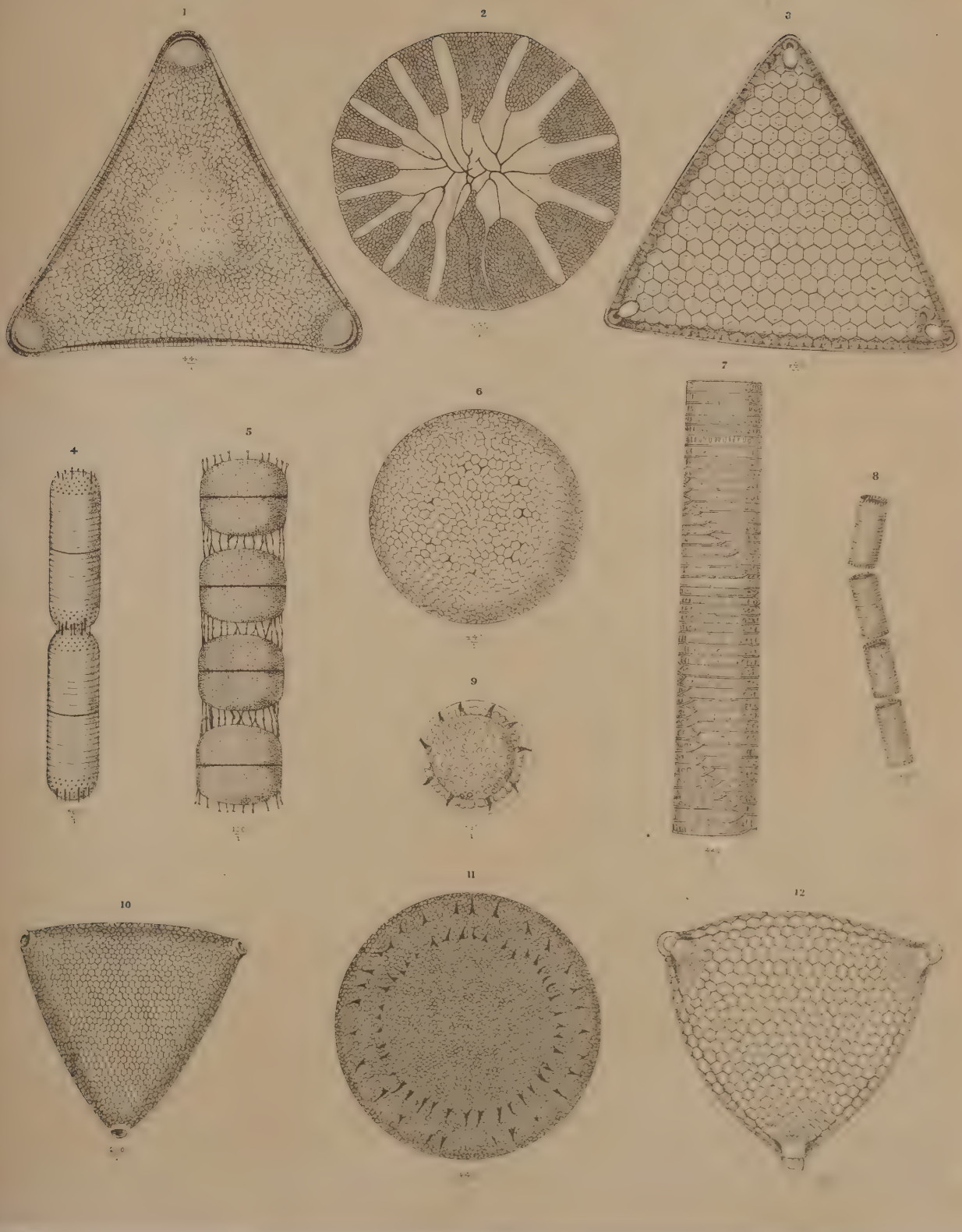
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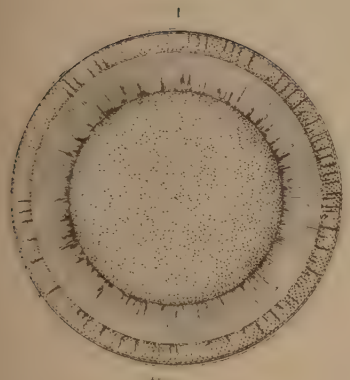

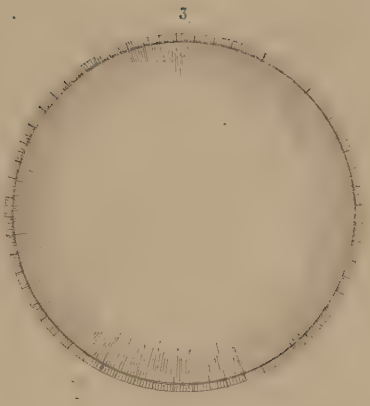

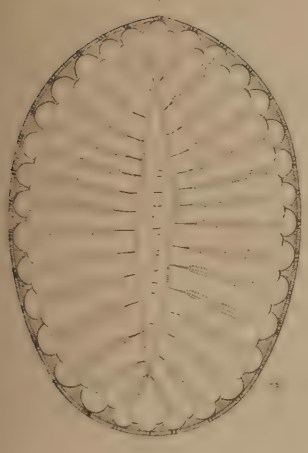

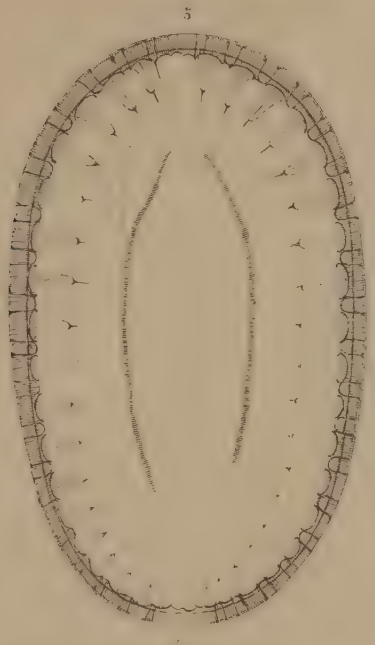

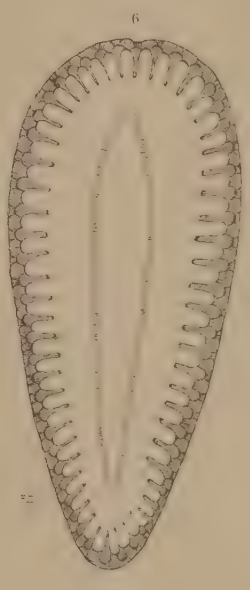

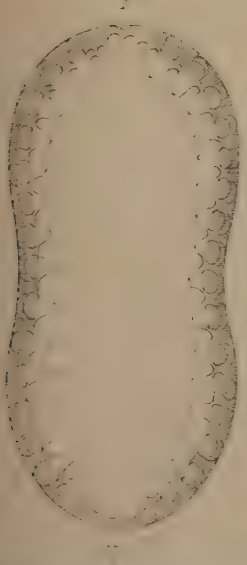

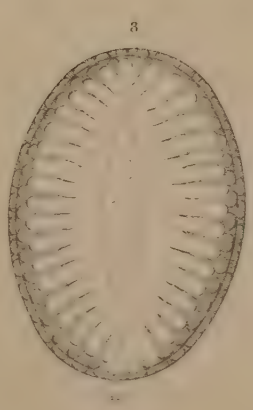

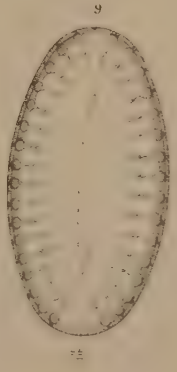

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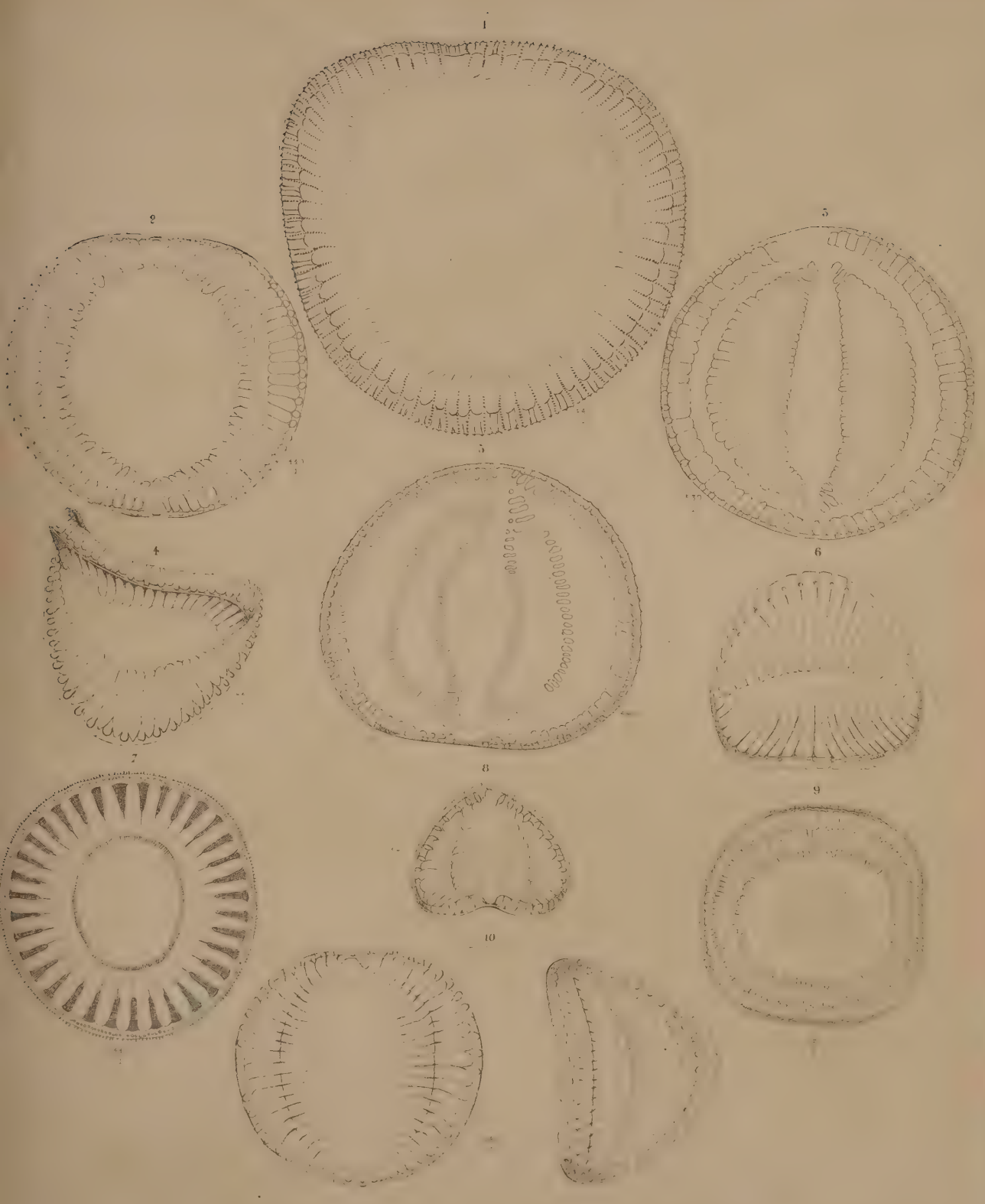
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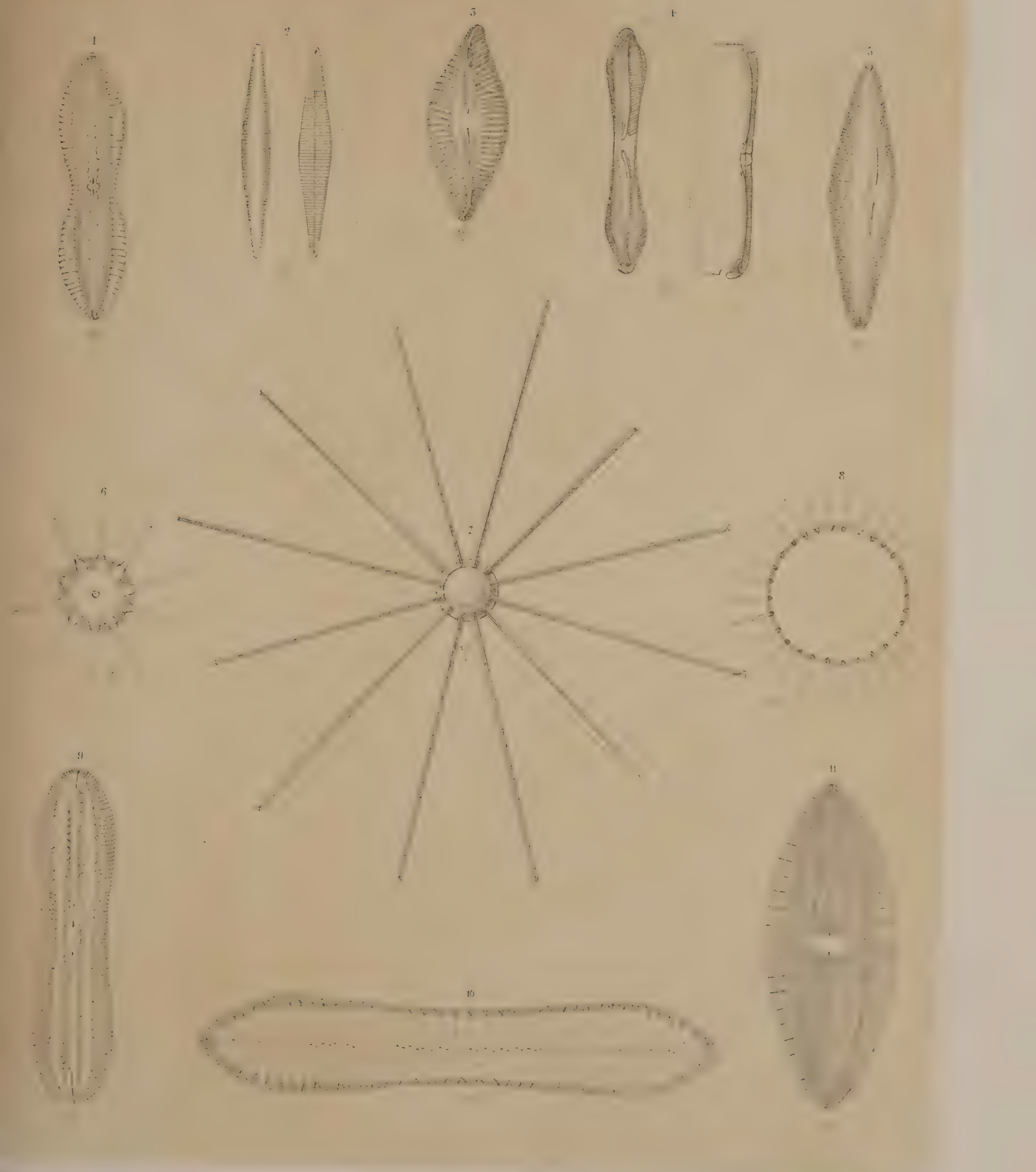
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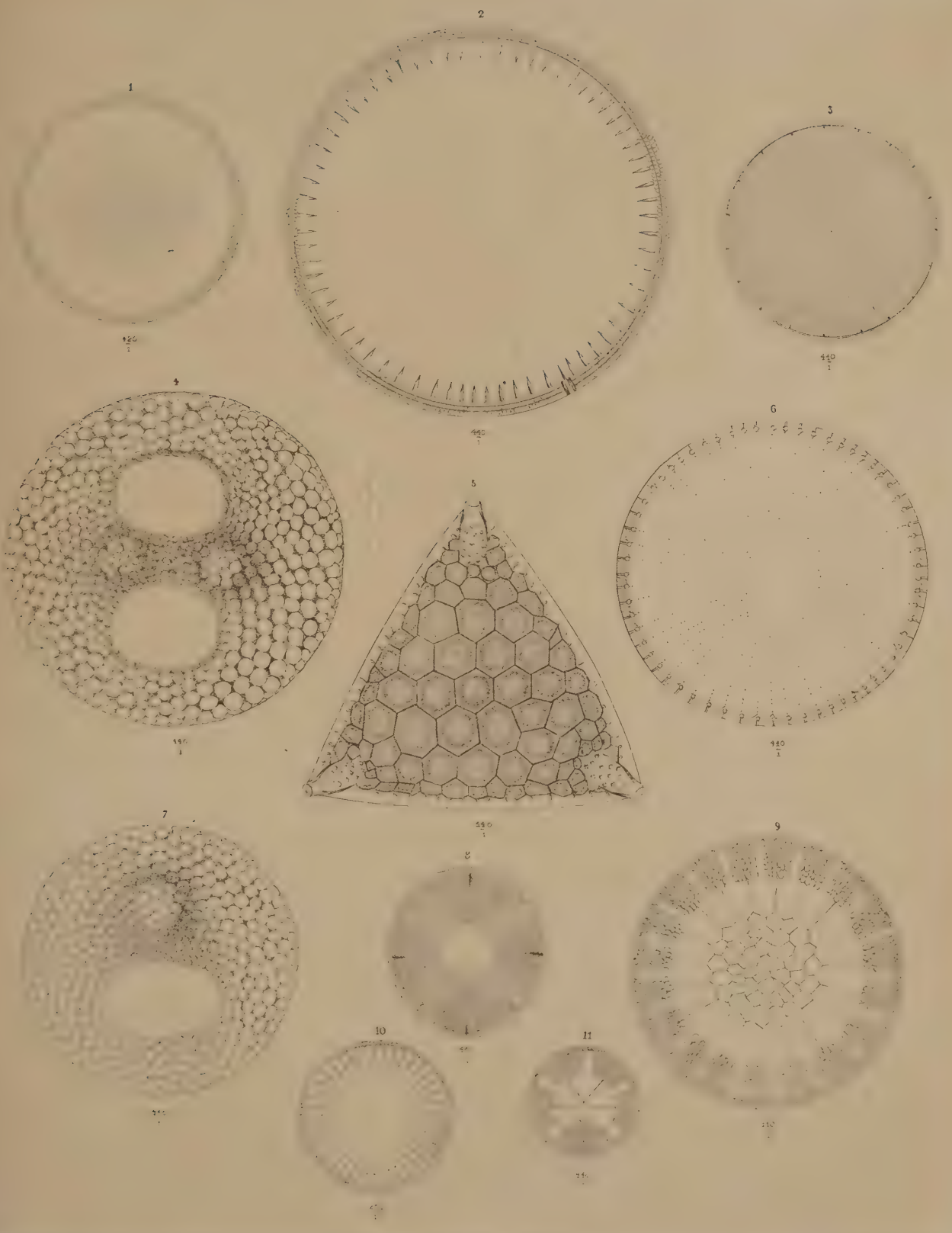
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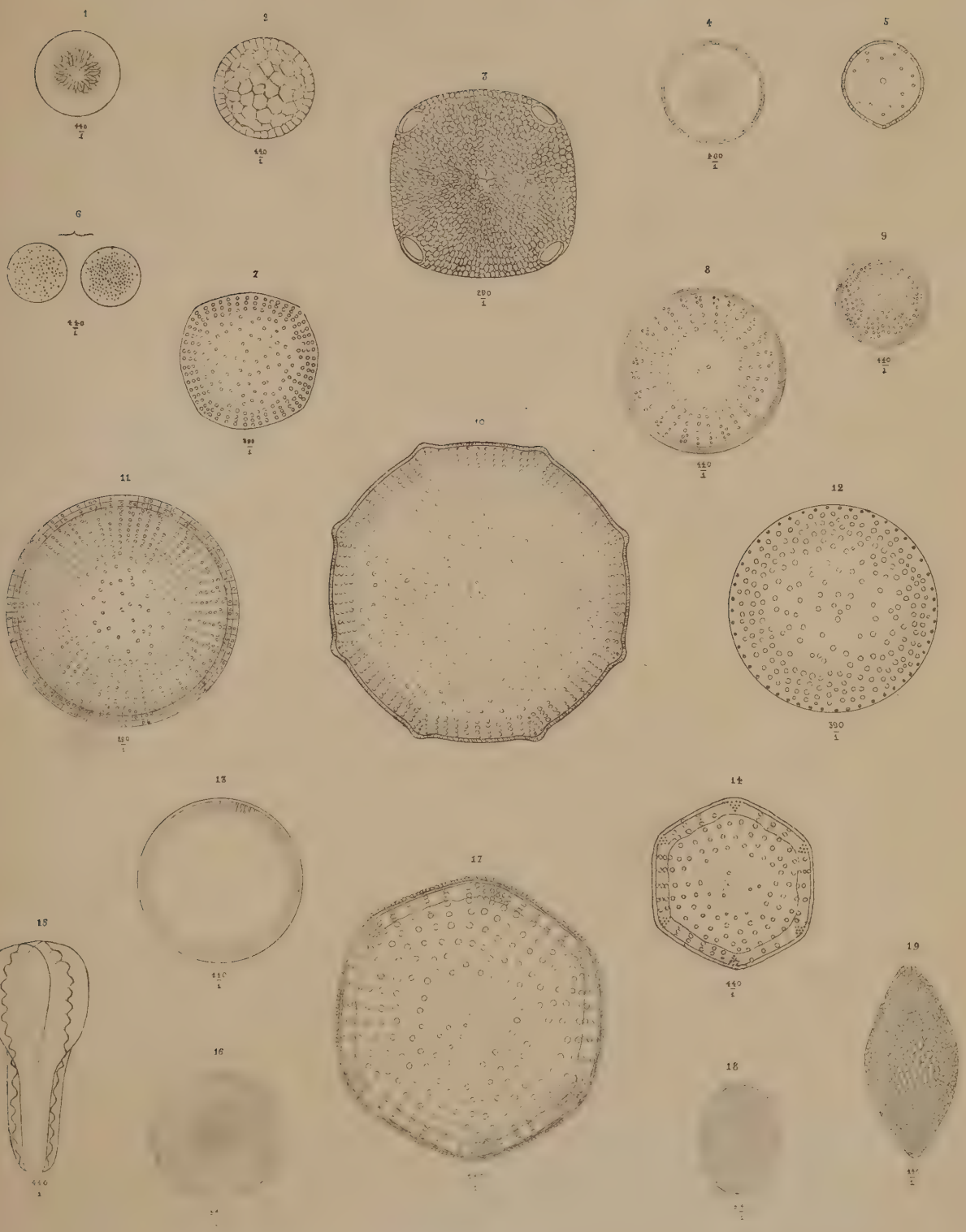
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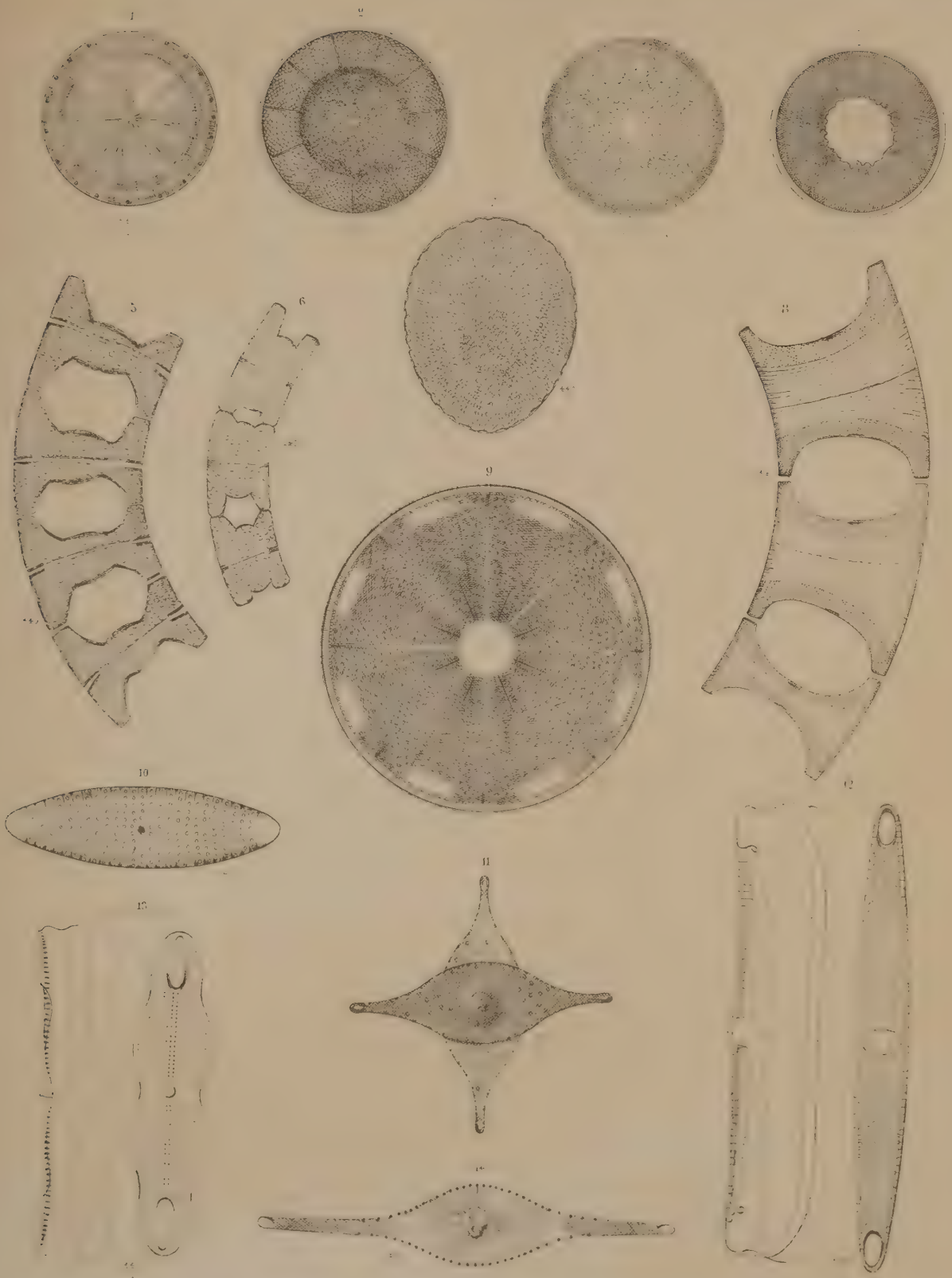
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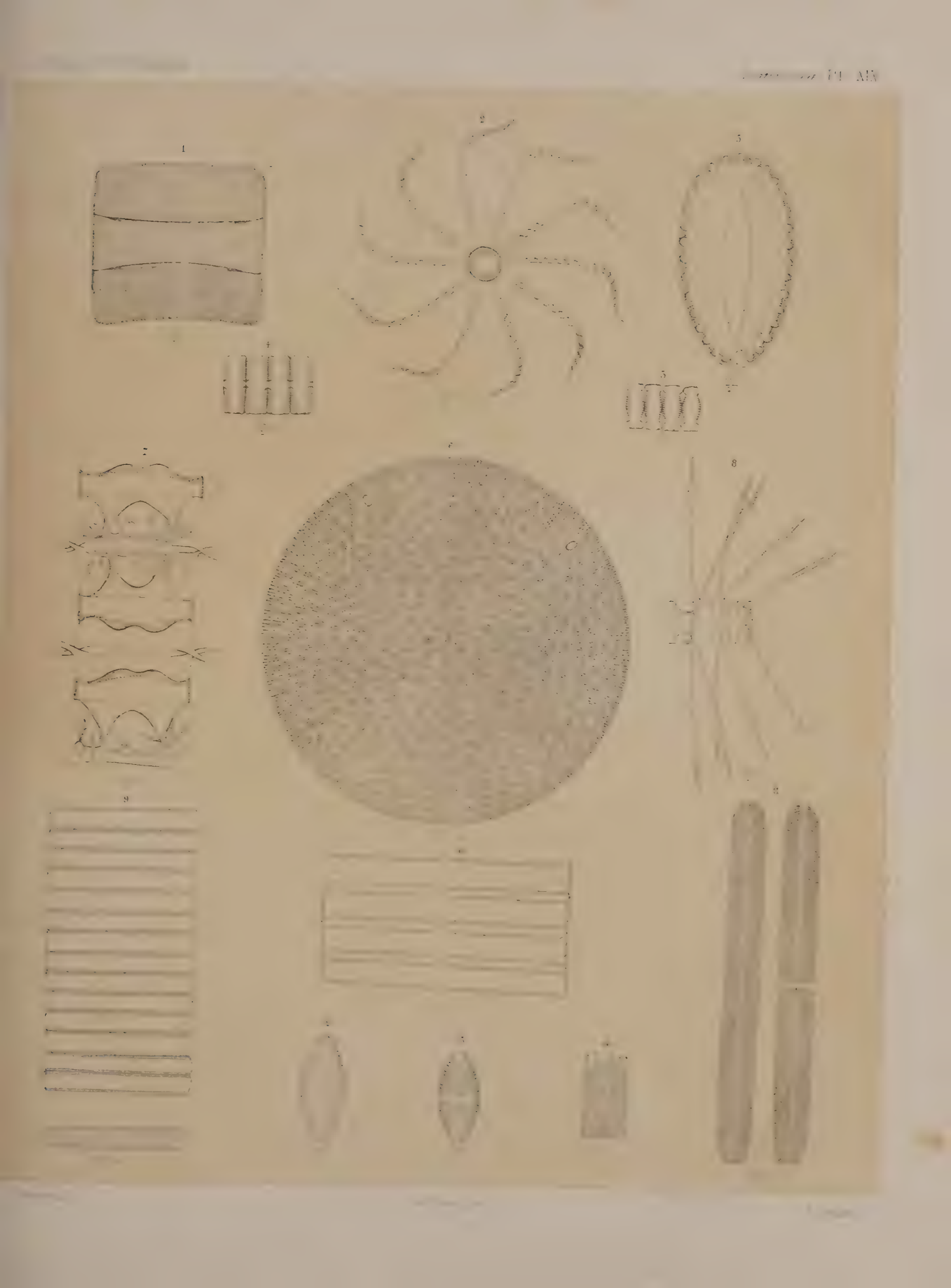

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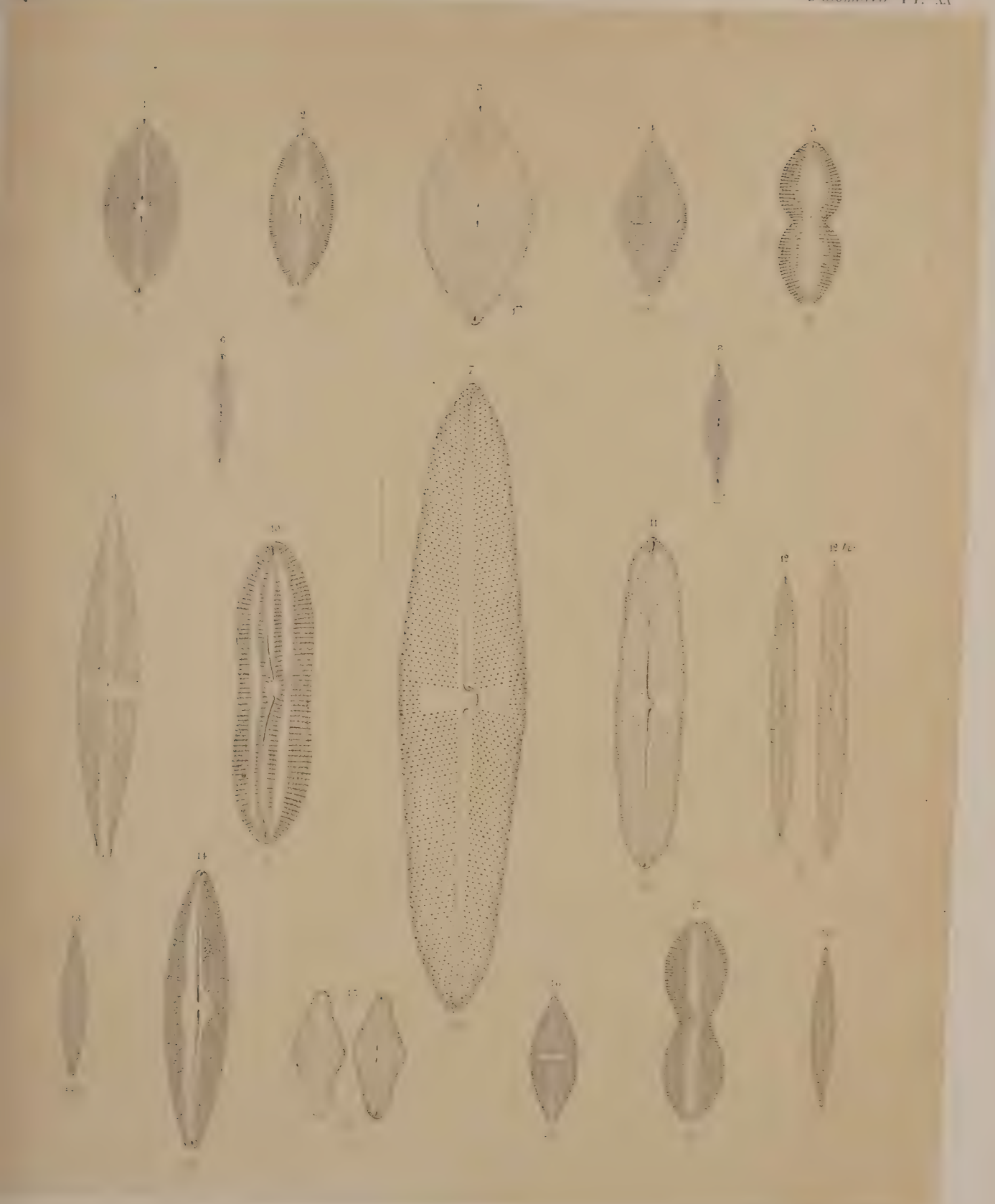

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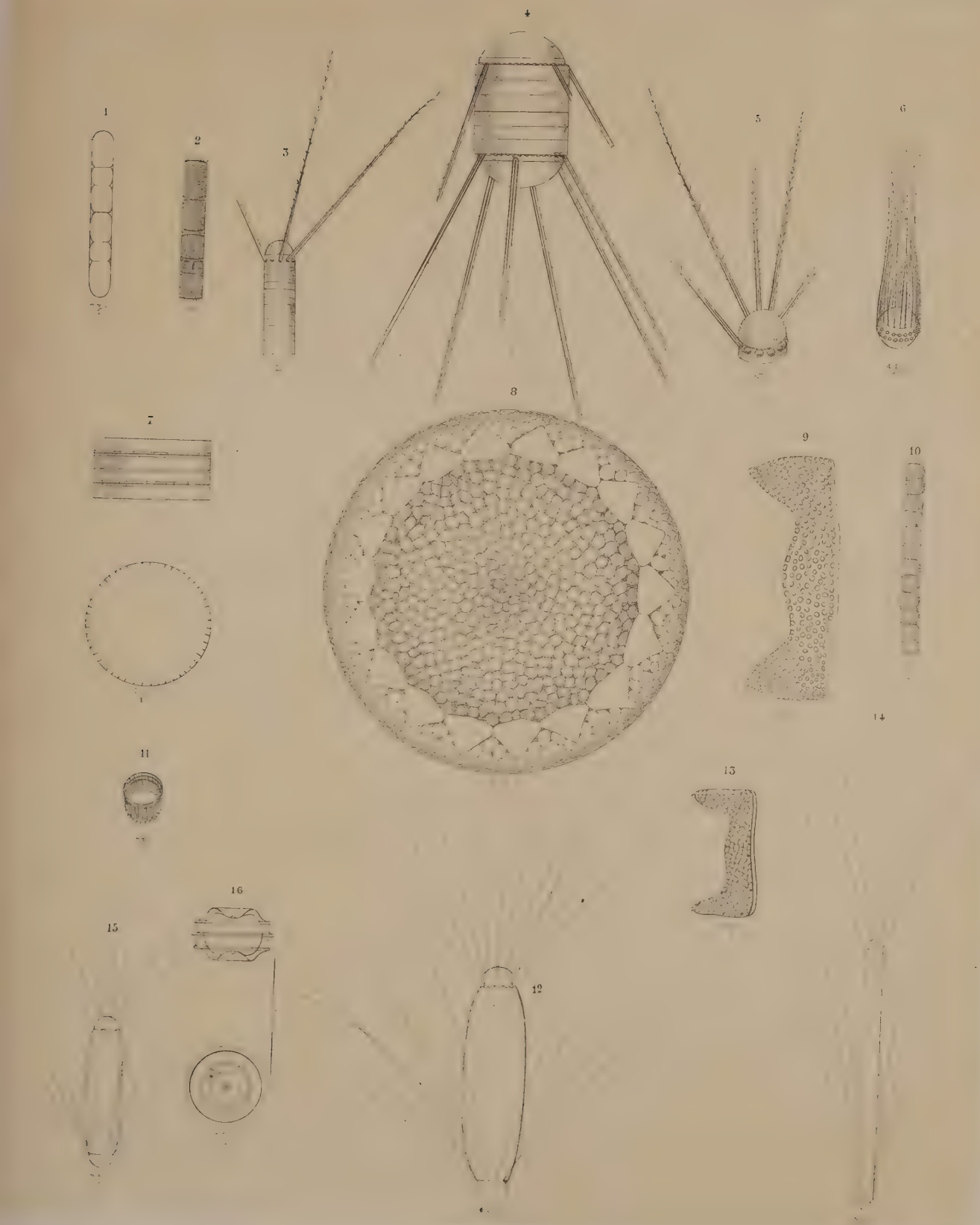
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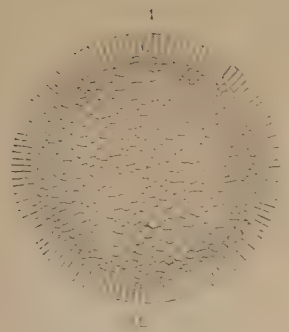
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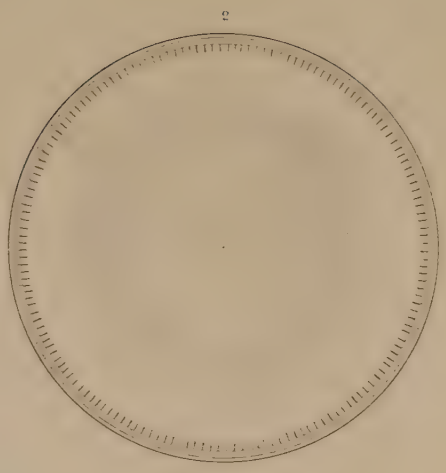
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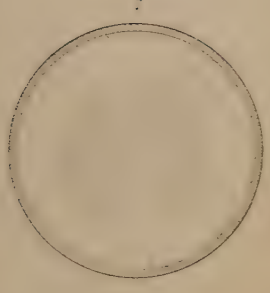
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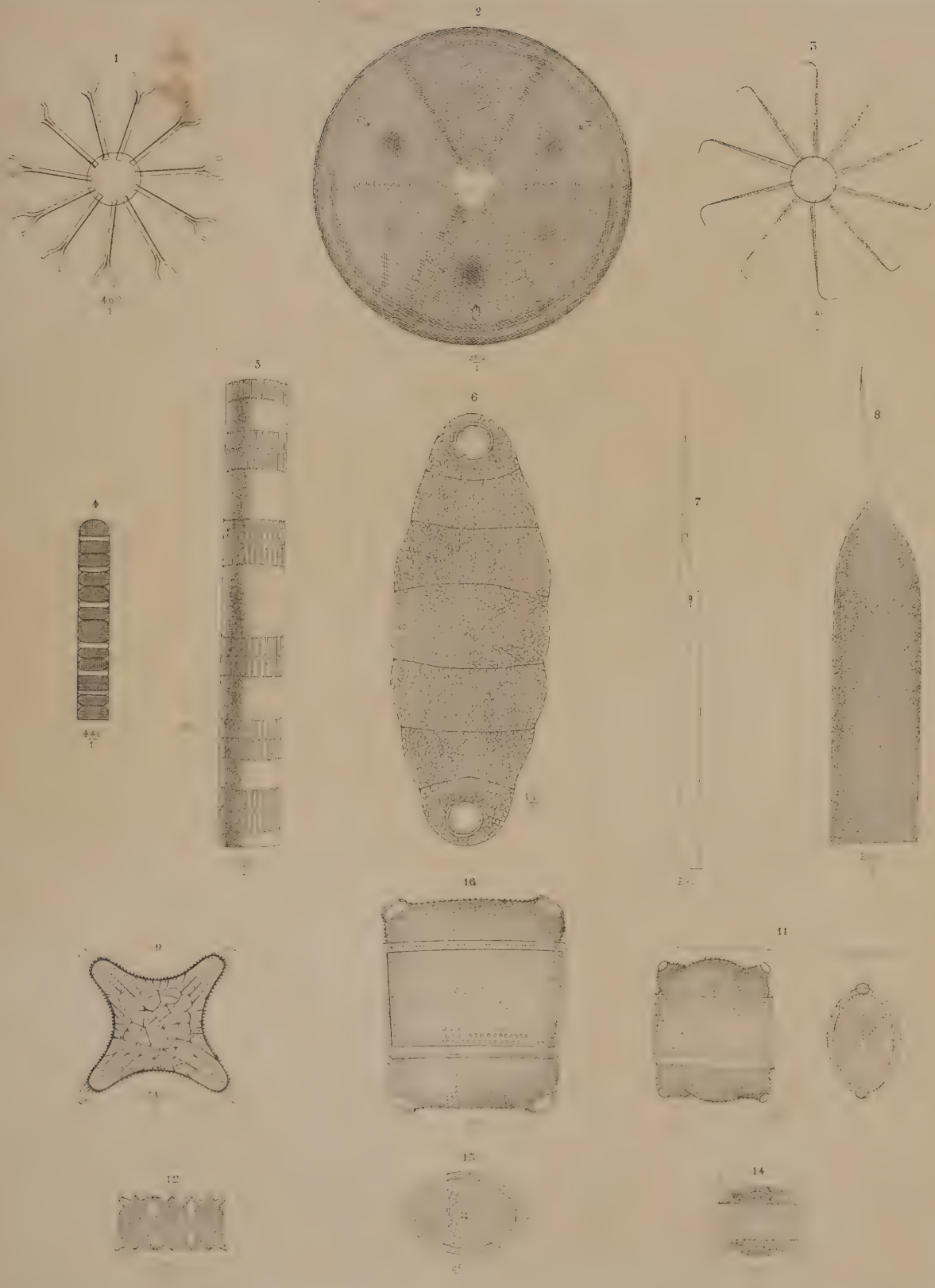
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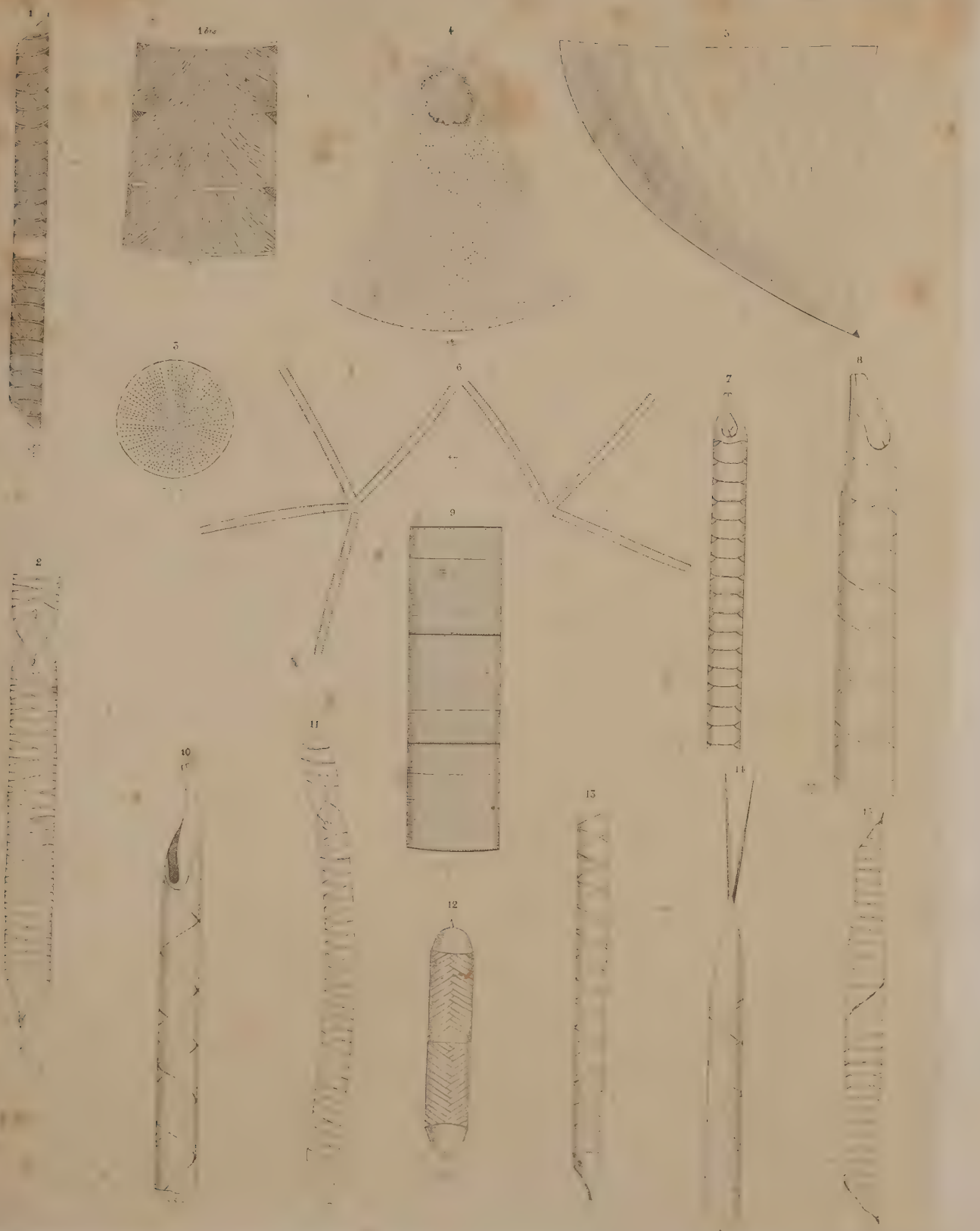
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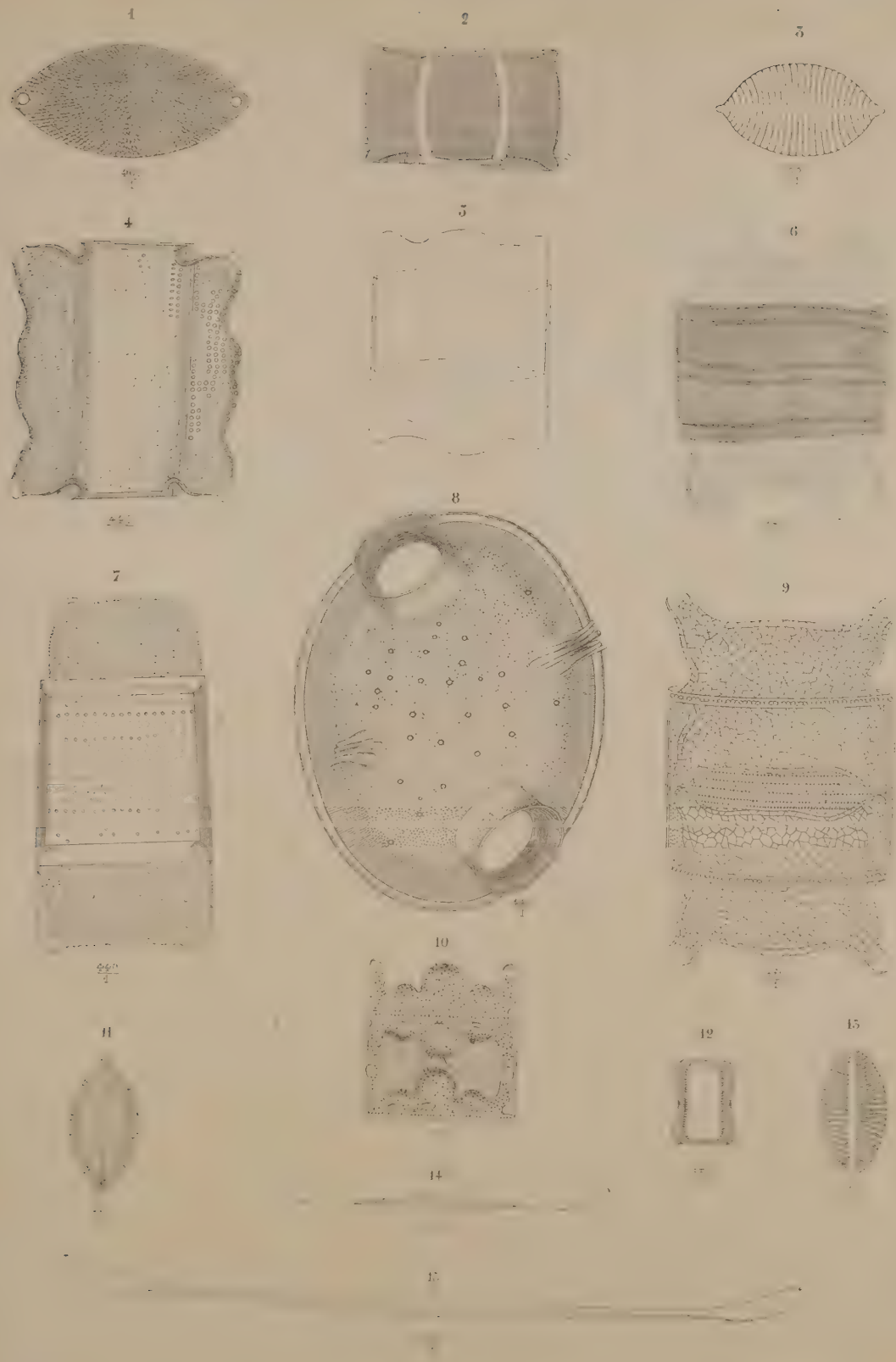
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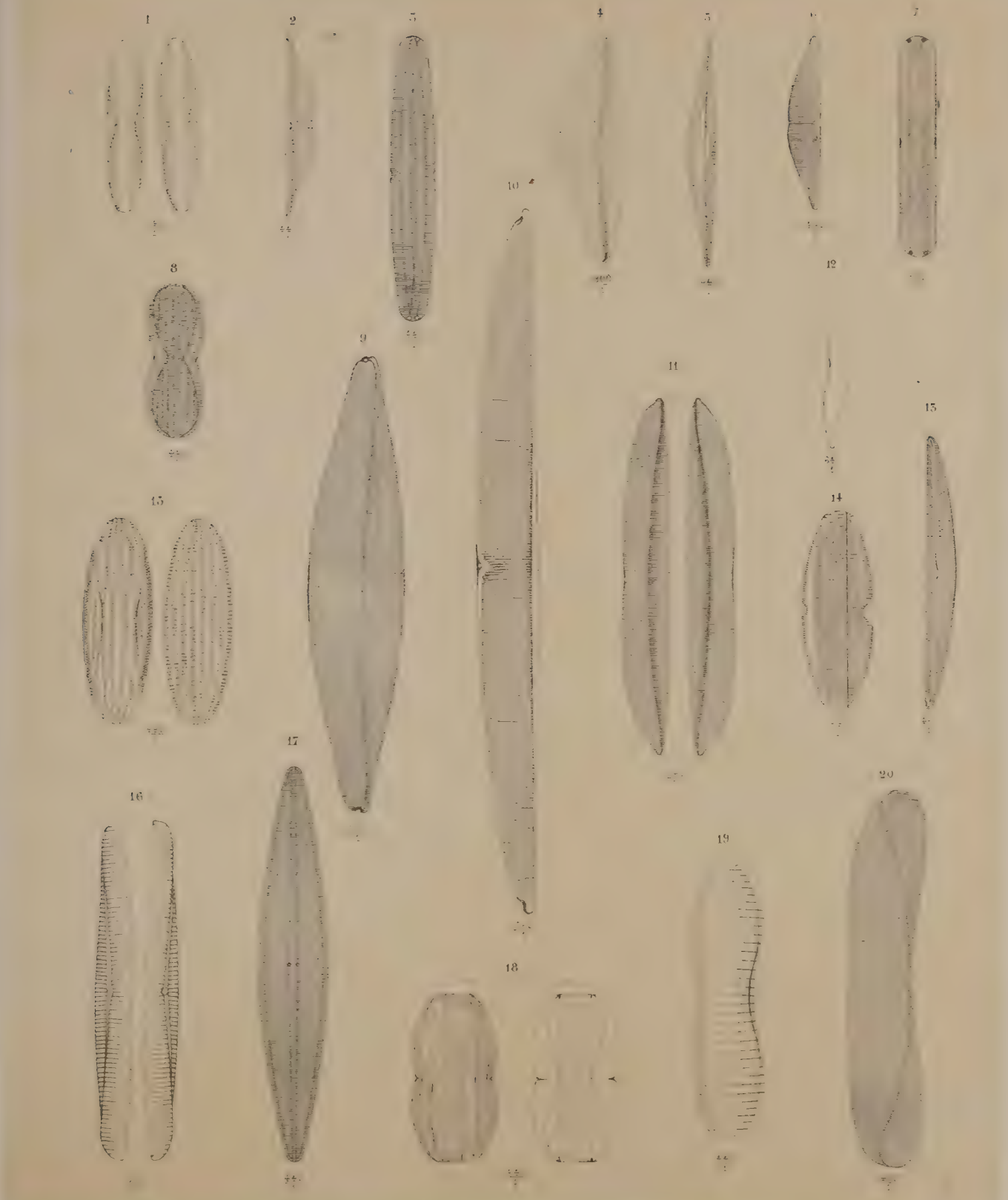
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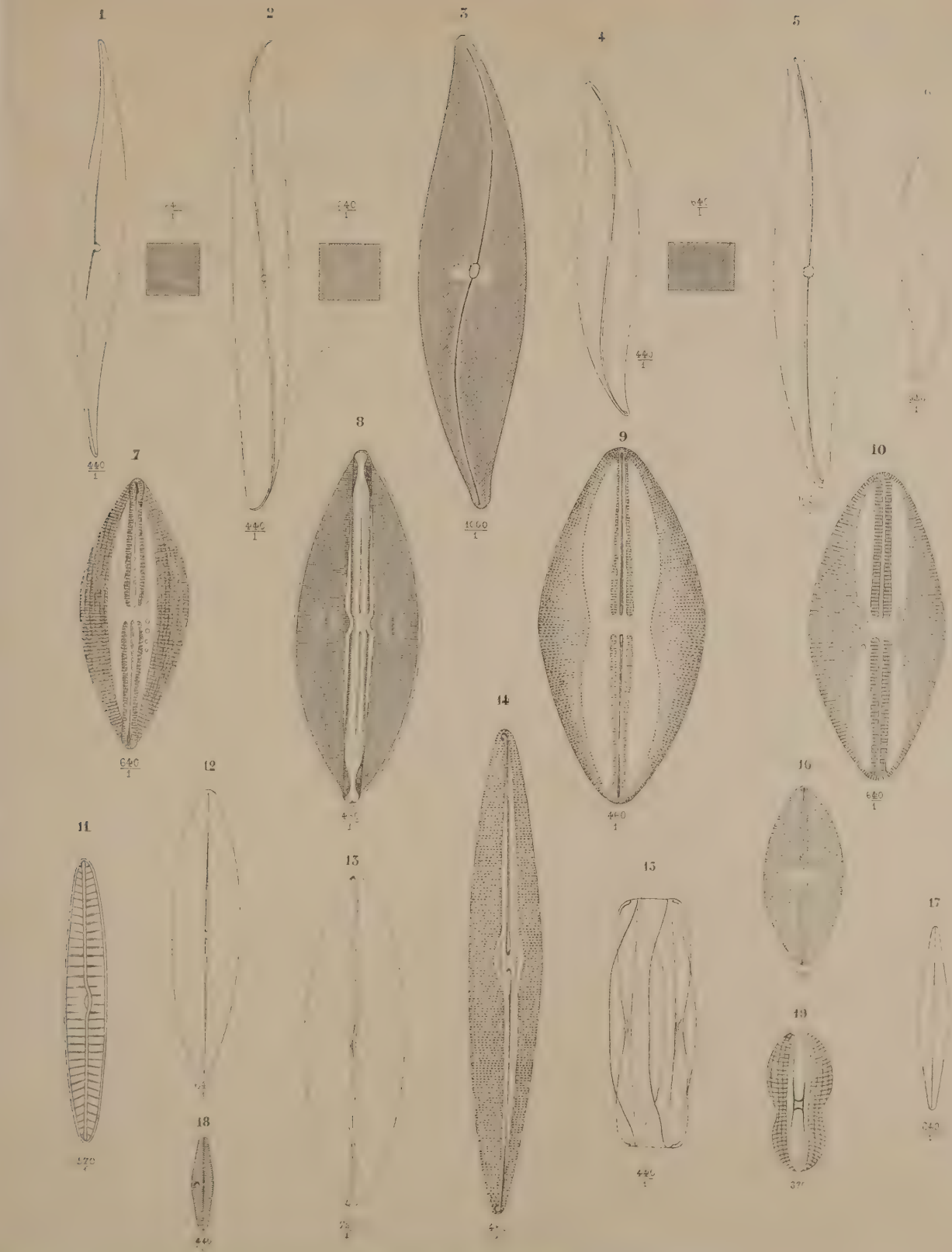
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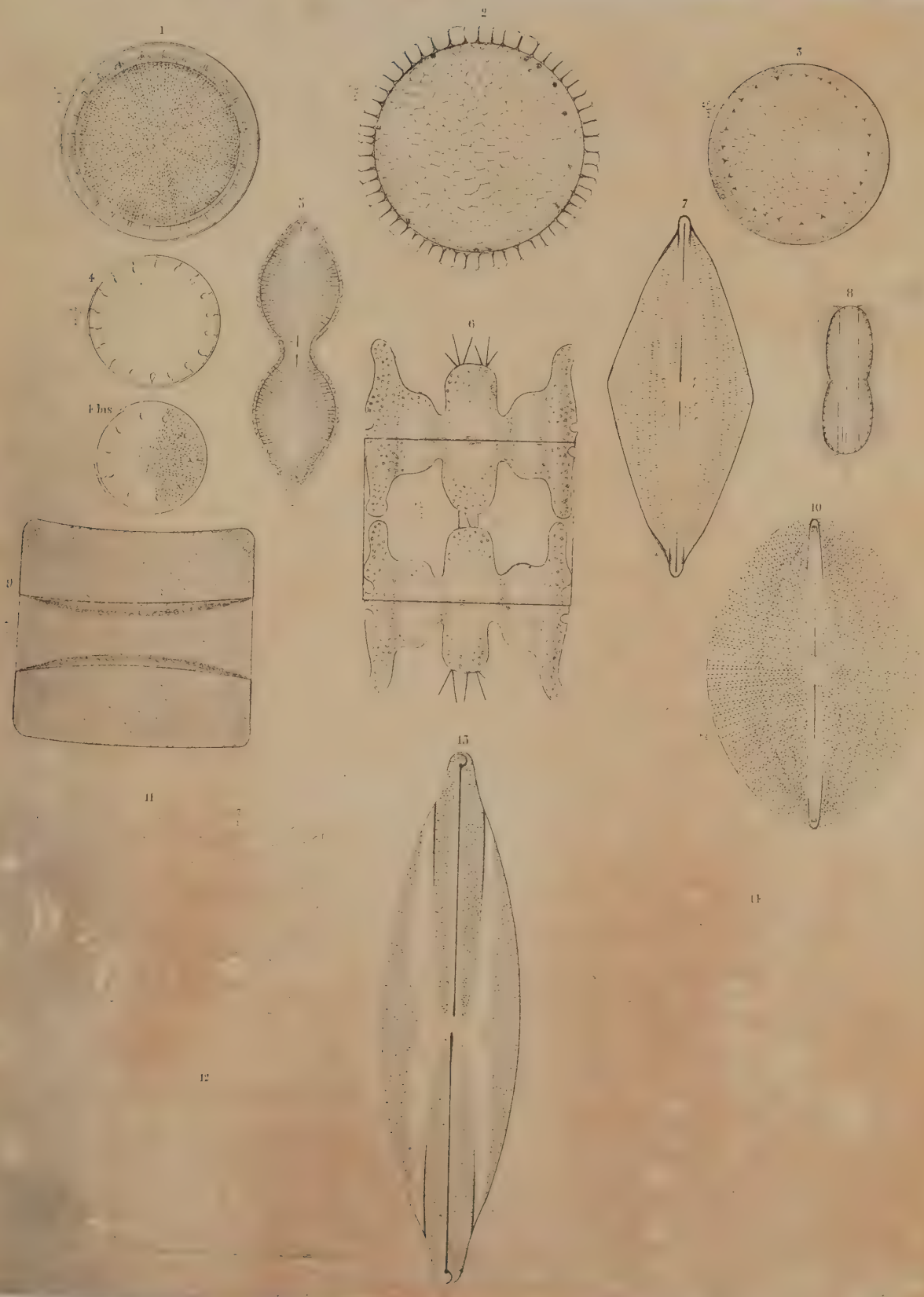
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